FEBRUARY 1952

Journal

VOL. 44 • NO. 2

AMERICAN WATER WORKS ASSOCIATION

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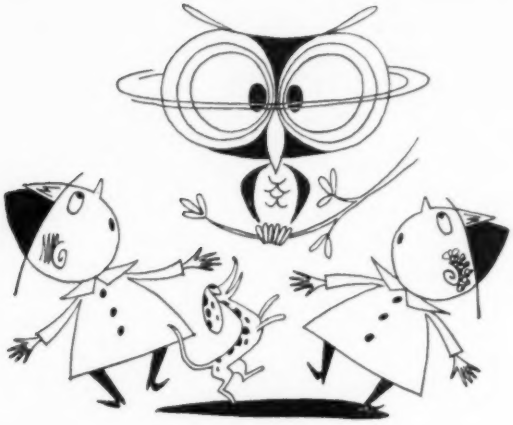
Head turns all the way around



Nozzle direction may be changed easily and at any time by simply loosening the bolts in the swivel flange and turning the head . . . The number and size of nozzle outlets can be changed by replacing the head, and without shutting off the water.

MATHEWS
HYDRANTS

Made by R. D. Wood Company Public Ledger Building, Independence Square, Philadelphia 5, Pa. • Manufacturers of "Sand-Spun" Pipe (centrifugally cast in sand molds) and R. D. Wood Gate Valves

Mathews Modernized Hydrants . . . Tops in Convenience and Dependability Compression-type valve prevents flooding • Head turns 360° • Replaceable head • Nozzle sections easily changed • Nozzle sections raised or lowered without excavating • Protection case of "Sand-Spun" cast iron for strength, toughness, elasticity • Operating thread only part to be lubricated • All working parts contained in barrel • A modern barrel makes an old Mathews good as new • Available with mechanical joint pipe connections

From mammoth to midget...
according to your requirements
120" Lock Joint Reinforced Concrete Pressure Pipe and 16" Lock Joint Prestressed Concrete-Cylinder Pipe

Whether your daily water consumption demands be 3,000,000 gallons or hundreds of times that figure, Lock Joint Pipe Company is prepared to provide the supply line you need.

In the last few years the Company has supplied not only hundreds of miles of large diameter pipe but also more than a million feet of 16" to 24" pipe for municipalities and industry. This has been made possible through the establishment of three permanent manufacturing plants. Lock Joint Concrete Pressure Pipe from 16" to 42" in diameter, produced at these plants, can be shipped economically to all parts of the country for major installations and minor extensions.

Our representative will be glad to discuss with you any water supply or transmission project which calls for pressure pipe 16" in diameter or larger. You will find that Lock Joint Concrete Pressure Pipe's superior characteristics of long life, continuous high flow and negligible upkeep will recommend it above all others for any permanent installation.

LOCK JOINT PIPE COMPANY

Est. 1905

P.O. Box 269, East Orange, N. J.

Pressure Pipe Plants: Wharton, N. J.
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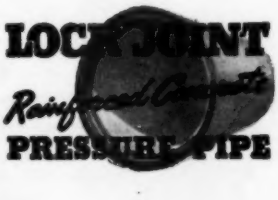
SCOPE OF SERVICES—Lock Joint Pipe Company specializes in the manufacture and installation of Reinforced Concrete Pressure Pipe for Water Supply and Distribution Mains in a wide range of diameters as well as Concrete Pipe of all types for Sanitary Sewers, Storm Drains, Culverts and Subaqueous Lines.



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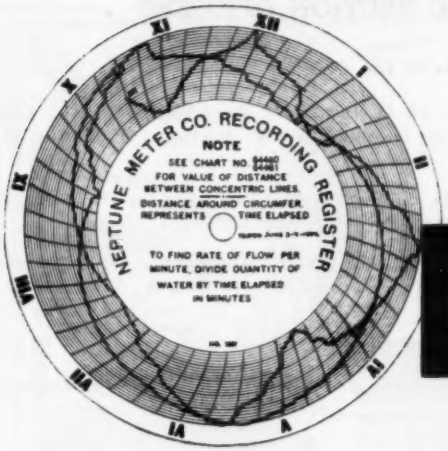

PROOF!

that you can get more revenue from a sensitive accurate meter

This chart is an actual record taken from a house with a toilet leak of about 1/10 gallon per minute. It proves the value of an accurate sensitive meter—because a meter not sensitive enough to register at this low rate of flow would never have picked up this leak

—and the water company would have lost the revenue on approximately 149 gallons per day, or about 13,500 gallons per quarter. Instead of 1/10 gpm, leakage might have run as high as 1/3 gpm, with that much more loss to the water company.

Moral — Keep your water meters sensitive by keeping them in good repair; and you will get maximum revenue from your water.

NEPTUNE METER COMPANY
50 WEST 50th STREET • NEW YORK 20, N. Y.

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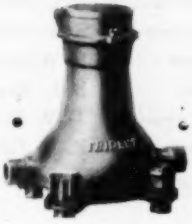

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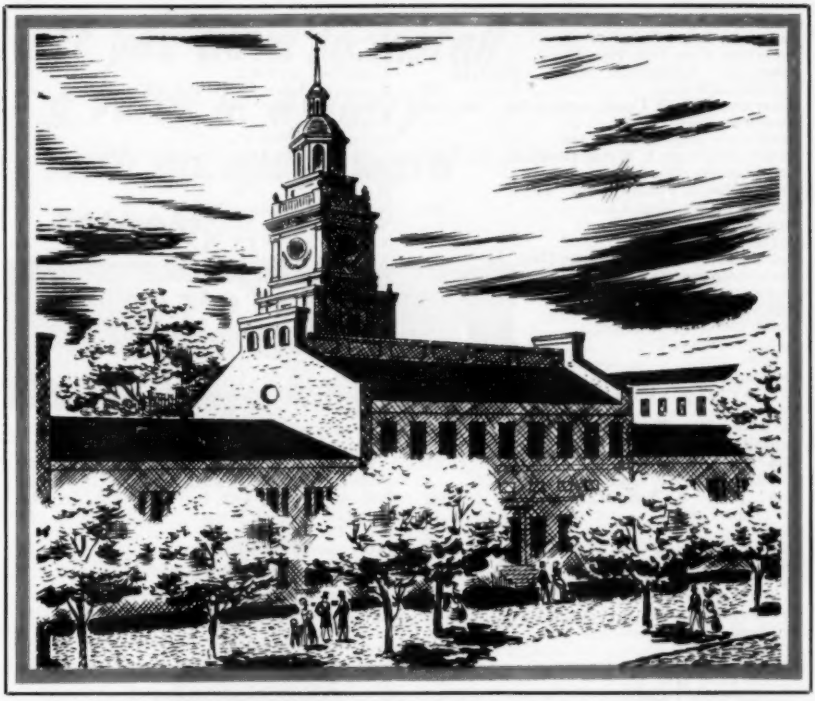

Philadelphia's Independence Hall, where the Liberty Bell is housed, as it looked 100 years ago

Philadelphia has cast iron water and gas mains in service that were laid well over a century ago. One of them is America's oldest cast iron water main, still functioning despite the radically changed conditions of street traffic and underground utility services in 100 years. The fact that cast iron pipe, laid generations ago, withstands the shock of heavy-duty traffic and the stresses caused by congested underground structures, amply demonstrates its shock-strength and beam-strength. Because of these strength factors and effective resistance to corrosion, cast iron water and gas mains, laid over 100 years ago, are still serving in the streets of more than 30 cities in the United States and Canada. United States Pipe and Foundry Co., General Offices, Burlington, N. J. Plants and Sales Offices Throughout the U. S. A.

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NUMBER EIGHT OF A SERIES

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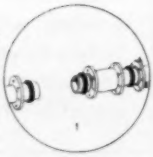
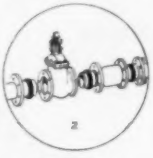
If you have to install a valve in a hurry-- with an eye toward economy....

...specify EDDY Cutting-in Valves and Sleeves



After excavation and removal of section of pipe, glands and gaskets are placed on pipe and sleeve. The sleeve is then pushed into position.



Valve is placed between pipe-end and sleeve, and pushed home against pipe. Sleeve is seated into bell of valve.

Glands, gaskets, bolts and nuts are then assembled at the 3 joints and tightened, using a ratchet wrench only.

Since 1849 EDDY For Long Service

EDDY VALVE COMPANY

A Subsidiary of James B. Eddy & Sons

WATERFORD, NEW YORK

Starting with step "1" above, two men with a ratchet wrench can install an Eddy Mechanical Joint Cutting-in Valve and Sleeve on an existing pipeline in less than 25 minutes. Every joint is bottle-tight under pressure, without caulking or lead-melting. Thus, the work can be done in any kind of weather, or in a flooded trench. Valves meet AWWA specifications; are available in 3 to 12" sizes for sand-cast and centrifugally-cast iron water pipe. Stock up now, for speedy installations.

COMING MEETINGS

AWWA ANNUAL CONFERENCE

Kansas City, Mo. May 4–9, 1952

Reservation forms have been mailed to all members, and all reservations will be cleared through the A.W.W.A. office. The hotels have agreed to accept no reservations for the 1952 Conference except as they are requested on the standard form prepared by the A.W.W.A.

March

20—New England Section Business Meeting at Hancock Room, Hotel Statler, Boston, Mass. Secretary: G. G. Bogren, Weston & Sampson, 14 Beacon St., Boston 8, Mass.

24–26—Southeastern Section at Bon Air Hotel, Augusta, Ga. Secretary: T. A. Kolb, 89 Alexander St., Charleston, S.C.

26–28—Illinois Section at LaSalle Hotel, Chicago. Secretary: J. Leslie Hart, Western Sales Manager, U.S. Pipe & Foundry Co., 122 S. Michigan Ave., Chicago 3, Ill.

April

3–5—Arizona Section at Maricopa Inn, Mesa. Secretary: Harry S. Jordan, San. Engr., Bureau of Sanitation, State Dept. of Health, Phoenix, Ariz.

11–12—Montana Section at Northern Hotel, Billings. Secretary: Arthur W. Clarkson, Assistant Director, Div. of Sanitary Engineering, State Board of Health, Helena, Mont.

16–18—New York Section at Hotel Syracuse, Syracuse. Secretary: R. K. Blanchard, 50 W. 50 St., New York 20, N.Y.

17–18—Nebraska Section at Cornhusker Hotel, Lincoln. Secretary: E. Bruce Meier, Asst. Prof., Univ. of Nebraska, Lincoln.

24–26—Pacific Northwest Section at Davenport Hotel, Spokane. Secretary, O. P. Newman, Box 548, Boise, Idaho.

May

3—Kansas Section at Town House, Kansas City. Secretary, H. W. Badley, 640 Highland St., Salina, Kan.

6—Kansas Section Business Meeting Luncheon at Hotel President, Kansas City, Mo. Secretary, H. W. Badley, 640 Highland St., Salina, Kan.

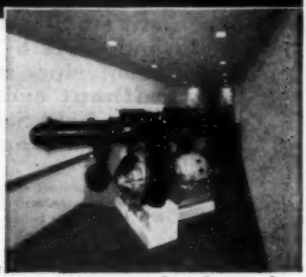
6—Missouri Section Business Meeting Luncheon, at Hotel President, Kansas City. Secretary, W. A. Kramer, Div. of Health, State Office Bldg., Jefferson City, Mo.

Now...Dallas Park Cities *are pumping with Economy!*

Portion of main pump room, Park Cities Water Treatment Project. Shown are 13 of the 22 Economy Pumps installed on this project.

In new Park Cities, Texas, water treatment plant

Economical operation over a period of years was a primary requisite of the pumps for Park Cities Water Treatment Project, Dallas. In selecting pumps, Powell & Powell, consulting engineers, drew up specifications which took into consideration cost of equipment, efficiency of each unit and efficiency of units operating in series, plus rigid structural requirements and refinements of mechanical detail. Under this very exacting evaluation formula, Economy Pumps, designed especially for water works service, supplied by the Lone Star Pump and Machinery Co., were selected on the Dallas County project.



View in University Park Booster Station, part of the Park Cities project. These Economy Pumps boost the pressure going to the overhead storage tank, located 5 miles from the treatment plant.

It pays to specify Economy Pumps for water supply. For detailed information and illustrated catalogs write today to Dept. AG-2.

Economy Pumps, Inc.

SEDGLEY AVE. AT 19TH AND LEHIGH, PHILADELPHIA 32, PA.

EVERY SMALL WATER PLANT OPERATOR SHOULD KNOW that he can CONTROL TASTES and ODORS EASILY

Ottumwa, Iowa Water Plant

George Ahrens, well known Iowa water works authority, says that "Every small water plant should know that there is a simple foolproof way of controlling tastes and odors."

At Ottumwa, they check and safeguard their tap water against taste and odor pollution. You, too, at any small water purification plant, can control tastes and odors by applying active carbon, which is foolproof, since it picks up and removes tastes and odors without causing any chemical change. Let our Threshold Service Men show you how. Write, wire or phone our nearest office today.

Note: This Advertisement is published with the idea of promoting production of uniformly palatable water, and the quotations from outstanding water works authorities should not be construed as being an endorsement for any particular product.

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Journal

AMERICAN WATER WORKS ASSOCIATION

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Journal

AMERICAN WATER WORKS ASSOCIATION

VOL. 44 • FEBRUARY 1952 • NO. 2

The Employment of Consulting Engineers by Small Water Utilities

By Grant S. Bell

A paper presented on Sept. 18, 1951, at the Kentucky-Tennessee Section Meeting, Louisville, Ky., by Grant S. Bell, Partner, Howard K. Bell, Cons. Engrs., Lexington, Ky.

WATER commissioners and elected councils in small towns generally have little or no experience in the employment of consulting engineers. Normally their first consideration in letting any contract is to obtain the lowest competitive bid. Thus, when a construction job poses the problem of plans, they naturally tend to apply the same competitive bid technique to the selection of the engineer, reasoning that they "cannot spend more than $500 without taking bids." What they forget, of course, is that they spend more than $500 on the services of their water superintendent and other personnel without requiring them to submit bids for their positions. And a consulting engineer is more a temporary technical employee earning a fee for his time and service than a merchant or a contractor selling materials, equipment, or construction.

Almost any town official, on the basis of the applications and interviews, is likely to consider all engineers well qualified and of equal competence. Inasmuch as public officials are required to conserve public funds, it undoubtedly appears logical to make the actual selection on a competitive price basis. As fees for the services of qualified engineers vary little—following closely the schedules set up by engineering societies—practically no savings can be realized by price competition.

It is interesting to note the means by which so many apparently equally qualified engineers are drawn into a competition. First, the project is usually discovered by some engineer in need of work, who is seeking to establish himself, or by an engineer of the promotional type—more of a business man than a professional—who is will-

ing to dedicate the greater portion of his operating costs to promotion. The qualified engineer is often too busy with work for his clients and too interested in reducing overhead costs to detach a man for continuous promotion work. In time, however, even he learns of the proposed project and hurries to the scene to "mend his fences." By getting in touch with the proper officials, he is usually given a chance to submit a proposal. Despite any superiorities which he may stress, however, he is most often classified with the rest of the "crowd," often because the officials are tired of interviewing and not interested in following up on the applicant's invitation to investigate works of his design. For one reason or another, local officials rarely make personal inspections of an applicant engineer's accomplishments.

Results of Competitive Methods

The result of open competition for consulting engineering contracts can be the employment of one of the least qualified engineers at a saving of a few hundred dollars. Such savings, often made at the expense of sound and thorough design, could involve the expenditure of many thousands of dollars on construction of extras, necessary because essentials were omitted in the original plans. These and other difficulties such as awkwardness and extra expense of operation of a plant of inferior design usually make the attempt to economize by saving on engineering a very costly one.

Frequent, too, as a result of keen engineering price competition, is the employment of the engineer who has the most time and talent for dealing with the officials and influential citizens and the time to keep abreast of the situation until a decision is made. This is the engineer who can exert the most political pressure. Unfortunately, ability in the one field does not necessarily betoken ability in the other. And although it is lamentable that the employment of engineers should be based on such aspects of competition, there is no question but that every consultant at some time and to some extent has had to compete on the basis of that irrelevancy.

Often an engineering design job is awarded to the engineer who gives the lowest "off-the-cuff" estimate of construction costs for the project. The official's greatest problem—that of financing—can apparently best be solved with the help of an engineer who will effect the greatest reductions in costs of the project. At the beginning of a project, many officials have the false impression that the engineer guarantees the cost of the construction. The engineer, however, is not being paid for the construction. He cannot guarantee the prices that contractors will quote, as he has no control over their bids. It is their bids, instead, that provide the guarantee. The engineer can only estimate from past bids of contractors on similar work what they will bid on the next project.

Need for Specifications

Competitive bids are never of any value without exact specifications for the work to be performed. Contractors cannot bid on a construction using their own ideas of the extent and quality of work involved. The one who had the least idea of what the job entailed would probably get the contract. Similarly, the engineer least well acquainted with the requirements is likely to find least to do and will, thus, perform the design at the lowest cost.

The engineer's task is a sincere representation of a client's interests in a field in which the client is unable to represent himself. The most important characteristic of an engineer, therefore, is integrity. It follows that he cannot meet this responsibility to a client unless he has the background of education and experience to equip him thoroughly. Thus, overemphasis on promotional and sales techniques should be regarded with suspicion. Exact specifications for engineering integrity cannot, of course, be written; nor can a price be placed on this quality. From a technical point of view, it is impossible to specify the degree of originality, the judgment required in selections and the degree of detail to be shown on plans for a projected water plant. Specifications that will enable engineers to bid on exactly the same design have never been devised and never will be.

Size of Engineering Organization

Some officials who require plans for a small project are unduly impressed by bigness in an engineering organization. On large jobs, a considerable expenditure for engineering administration is required, but it is unnecessary for the design of small projects. Large organizations not geared for small jobs may be awkward and wasteful on them. They also have a tendency to delegate the small jobs to the less experienced individuals in their organizations. In the small engineering organization, it is possible for the best qualified members of the firm to give personal attention and leadership to every project handled.

Summary

Considerations in the procurement of consulting engineering service can be summarized in the following thirteen points:

1. Schedules of engineering fees should be obtained from the American Society of Civil Engineers or the state society of professional engineers. These schedules are based on long experience and much thought concerning the cost of sound engineering.

2. The engineer who has previously given good service to a client even on small jobs will naturally best understand the client's problems. That engineer should be best qualified for the big job if it is within the capacity of his organization.

3. Largeness in an engineering organization may be a detriment on small projects unless the firm is geared to handling that particular type of work.

4. Advantages of cost and availability are with the engineer nearest a client. Time for and cost of travel produce neither results for the client nor income for the engineer.

5. State registration of an individual as a professional engineer does not necessarily mean ability and experience in water works design.

6. Engineers who practice in a broad field should generally not be selected for specialized design. With the rapidity of new developments, it is difficult enough to keep up to date in just one specialized field.

7. A library of technical data, specifications, and plans is of untold value to an engineer and to his client. Only engineering firms which have been practicing for a number of years can be expected to accumulate an adequate library of such information.

8. Rapidly expanding engineering organizations should be avoided, as qualified extra design help in these times is practically nonexistent. Many

years are needed to develop an engineer into a designer.

9. The best recommendation of an engineer is continuous service to clients and repeat performances for them. A list of work done will speak more authoritatively than any letter of recommendation.

10. More weight should be given to the selections of water works managers who regularly employ consulting engineering assistance than to the selections of governing bodies who know the engineers only by their solicitations and have little opportunity to evaluate their work. The engineer who can influence the most people in a sales competition is not necessarily the best one, if it is engineering service that is being bought.

11. Secret investigation and selection of the consulting engineer should be practiced. The best managers are selected in this manner, and it seems logical to do so for engineers.

12. In engineering contracts, as distinct from those for construction jobs, the variable and the basis of selection should not be the price. Qualified engineers accept standard fees. The variables on which the selection should be based are the intangibles of extent and quality of engineering services. Engineers are never equally qualified, particularly in specialized lines of design.

13. The final objective of engineering design, of course, is not a perfect set of plans and specifications, but the perfection of the structure or facility they represent. Without adequate engineering supervision, contractors may be permitted to misinterpret, or, in their own interest, to disregard plans. On the other hand, clients performing their own construction without engineering supervision generally obtain the worst results for lack of construction experience and equipment and because they are free to disregard the plans in order to ease the task and to effect apparent economies. Such failures to follow plans have "botched" more jobs for small towns than poor planning. Omission of suitable engineering supervision of construction is false economy in the extreme.

Municipal Financial Consultant Services

By Townsend Wainwright

A paper presented on Oct. 31, 1951, at the Florida Section Meeting, Daytona Beach, Fla., by Townsend Wainwright, Cons. on Munic. Finance, Wainwright, Ramsey and Lancaster, New York City.

THE services of a municipal financial consultant and the problems he undertakes to solve are many and varied. Each problem in municipal finance presents some angle that is new and unique and requires a type of treatment that can be applied only to the particular situation.

The depression of the early Thirties had unfortunate effects upon the finances of all types of governmental units in every area of the country. In Florida, the real estate bubble burst in 1926, and the municipal difficulties there started before those of the rest of the country. The defaults and serious debt difficulties that arose at that time were not new factors in municipal finance. They were a repetition of an ancient tradition of borrowers. Toward the end of the fourth century B.C., thirteen Greek municipalities belonging to the Attic Maritime Association had contracted loans with the Delos Temple. Two of them defaulted completely in their payments and eight defaulted partially.

In the United States, more than 200 years elapsed between the founding of the first colony and the date of the first municipal default. In 1839, Mobile, Ala., committed the first major default recorded in the United States. Other defaults occurred as a result of the depression of 1837, and each succeeding depression during the next century precipitated new defaults—some because of the issuance of railroad aid bonds; others because of the collapse of real estate booms; several from difficulties incurred by irrigation, drainage, and reclamation projects; a number because of the aftereffects of the Civil War; and others for purely local reasons. Not all defaults occurred during depressions, and very few were the result of absolute bad faith.

The author was not involved in many "workout" jobs in Florida, with all the attendant litigation between bondholders' committees and defaulting communities. It was during the early Thirties, largely in New York and in New Jersey, that he gained his experience. In those years, much of his work involved the reorganization of existing debt structures, the funding of accumulated floating or current debts, and the refunding of long-term debts with maturities extended over several years and in amounts that could be met from revenues without straining the communities' taxpaying capacities.

Cardinal Principle

In solving problems of large current-debt accumulations and poorly spaced payments of outstanding perm-

anent debt, one principle had to be observed if new money was to be obtained, or if it was necessary to have the cooperation of the holders of long-term bonds. This cardinal principle was that something had to be done to prevent the recurrence in the future of the same difficulties. The best approach to this problem at that time was expressed in the "cash-basis" law of New Jersey, Chapter 60 of the Pamphlet Laws of 1934. This act authorized the funding of floating indebtedness by the issuance of 1- to 15-year serial bonds, but communities that availed themselves of the financing provisions of this act were required to balance their operating budgets on a strict cash basis during the period that such bonds remained outstanding. This fundamentally sound approach to municipal financing was soon accorded general recognition, and the provisions of the act were incorporated into the general bond and budget laws of the state when they were revised in 1935.

The author was active in the creation of both the laws mentioned and also contributed to the writing of similar provisions into the laws of other states and the charters of several leading cities. In refinancing the debt of Tampa, Fla., a covenant on the operating budget which is almost identical with the cash-basis law was incorporated into the contract between the city and its bondholders. The same practice was followed in Knoxville and Chattanooga, Tenn.

New Financing

Many communities that needed rearrangement of their debt structure also required new improvements. Until their permanent financial structures were established on sound bases, the markets for any new-improvement issues, of course, were closed to these cities. When it could be demonstrated, however, that their financial affairs had been worked out soundly, money for any reasonable amount of new improvements could be obtained at fair interest rates.

An example of new-improvement financing is provided by the state of Tennessee. In 1936 the state's debt structure was in the worst possible condition. The total obligations were approximately $130,000,000, and certain revenues were pledged irrevocably to particular bond issues. Some issues had sinking funds accumulated for their payment; others did not. Some of the sinking funds could not be invested, and funds for the payment of certain bonds simply were lying idle in cash. Virtually none of the state's debt incurred since the Civil War had ever been repaid. Each successive issue that matured was simply extended by a refunding issue. The state's credit was poor; the lowest interest rate for any of its outstanding long-term bonds was 4 per cent; and most rates were higher.

Through the application of new principles of finance and legislation resulting from what might be called new legal thinking, the structure of Tennessee's $130,000,000 debt was completely rebuilt into an orderly payment program that could easily be met from normal revenues. The necessity of refunding was eliminated, and by 1939 the state was obtaining new money at 2¼ per cent; by 1941, at 1½ per cent; and, by 1946, some of its permanent borrowing cost 1 per cent and some as little as 0.75 per cent. Although a general decline in interest rates during that period accounted for some of the

enormous savings, the main reasons for the great improvement in the state's credit were the facts that its permanent-debt structure had been placed on a sound basis and that the maturities of its new-money borrowings were dovetailed into the new pattern of payments, which the state had demonstrated it could readily meet.

Need for Statements

The raising of new money on favorable terms by any municipal body involves primarily the ability to demonstrate that the money will be repaid. Economic situations are not, of course, improved by high debts, and poor debt structures are not conducive to good credit. Some communities fail to describe their credit positions to the investing public. A few years ago, the Washington Suburban Sanitary District found its credit deteriorating, simply because it had failed to publish sufficient factual data on its finances. The district was forced to undertake extensive borrowing to finance necessary water and sanitary sewer services occasioned by rapid growth in population after World War II. Although the district's financial structure was entirely sound, no investor could be sure of the conditions without the facts. People will not merely take the borrower's word that his condition is sound. As soon as this information was made available to potential bond buyers, the district's credit rebounded, and, within a year, its cost of borrowing decreased approximately 0.8 per cent.

Every borrower should make certain that clear and up-to-date statements of its financial condition are always available to its actual or potential creditors. Such practice is merely good business. A municipality cannot fool people about its finances. The consultant's job, of course, is not only to design sound financial plans, but to arrange for all information to be available that will allow the buyer to appraise the intrinsic worth of the security properly. Obviously the consultant's ability to execute this function properly is money in the bank to his client.

Relation to Water Works

Important services can be furnished by a consultant on municipal finance for water and sewage works improvements. If a Florida community needs money to expand water and sewer services, it is almost certain these new facilities should be financed by revenue bonds. Actually, the present constitution and laws of Florida render any other financing method impractical. Also, the public is gradually becoming more aware that a properly conceived revenue-bond issue for such purposes is a type of investment that is well worth investigating. In fact, the well conceived revenue issues of many communities actually outsell the ad valorem tax bonds of such communities.

Consultant's Duties

The duties of the consultant in financing water and sewerage improvements by means of revenue bonds are extensive:

1. The consultant must thoroughly acquaint himself with a knowledge and understanding of how much money is needed by the utility and exactly what it is needed for. Investors are aware that utility services, both public and private, must be expanded when the population increases. When money to finance such expansion is needed,

and when the only security for the repayment of the loan is a mortgage on the earnings of the utility, the investor will want much information about the physical properties of the utility before he will extend credit. By working closely with the consulting engineers, the consultant will obtain the information needed for passing on to the investor. Knowledge of the character and the necessity of the imimprovements is essential to the consultant before he can construct a sound, feasible financing program.

2. The consultant must study the past and prospective financial operation of the utility and develop a suitable plan for financing the new requirements on the most reasonable terms obtainable. He must make certain that anticipated revenues will accrue in amounts sufficient to pay the operation and maintenance expenses of the utility, meet the principal and interest payments on outstanding obligations, provide for appropriate reserve funds, pay the costs of ordinary renewals and replacements, provide a moderate amount for extensions and improvements occasioned by normal growth, and allow a margin of safety for any likely loss in earnings from a downward trend in the community's economy. The safeguards incorporated in the plan of financing must offer adequate protection to the bondholder, but they must not interfere with the sound future operation of the utility.

3. After the general outline of the plan has been conceived, the consultant must confer with the bond attorney, who will prepare the indenture, or ordinance, under which the bonds are to be issued, and who will issue the opinion approving their validity. The drafting of the authorizing document requires the exercise of great care so that the entire plan adopted will operate in the manner intended. The financing plan and the indenture, or ordinance, must be reviewed with the city officials so that each detail and the reasons for each provision are thoroughly understood. The final document must, of course, be approved by the governing body.

4. After the financing plan is adopted and the legal proceedings are approved, the consultant must prepare the circular, or official statement, which will represent the formal offering of the bonds.

5. The consultant must advise when and to whom the indenture will be distributed and also supervise other constructive steps to publicize the offering.

6. The consultant must personally review all aspects of the program, including the circular and the indenture, with agencies that report on or rate municipal credits so that they may have the fullest possible data and understanding of the financing before presenting the reports to their clients.

7. The consultant must be available to the larger potential purchasers, such as banks, fraternal organizations, insurance companies, and estates, for complete discussion of the program. He must also be available to underwriting groups which are formed to bid for the bonds.

8. The consultant must advise the issuing body on appropriate conditions of sale, help the bond counsel draft the appropriate notice of sale, make known the publication time, and select a sale date that does not conflict with other offerings so that the attention of underwriters is not diverted.

9. The consultant must arrange for the signing and delivery of the new obligations.

10. After the sale the consultant must acquaint himself with the progress of construction and the earnings of the utility, and he must produce this information for interested individuals.

11. Many other incidental and collateral services may be performed that cannot properly be classified under any particular item above. It is sometimes necessary and advisable for the consultant to meet with local civic organizations to describe the work being done, and what is to be accomplished by financing. It is sometimes desirable and effective for the consultant to arrange luncheon meetings for members of prospective underwriting groups and officers of financial institutions to describe the issue and to answer questions concerning the project. In the final analysis, the consultant will take every action to achieve the best results for his client. The results that he obtains, of course, make his reputation.

The Official Statement

Certain information must be furnished to the prospective purchaser by means of a financial statement. In this statement some of the general data to be included are:

Nature and Economy of Community

An appropriate description of the community must be presented in the fewest possible words, together with charts, statements, maps, and pictures. Description of the community's location, the surrounding area, population characteristics, natural resources, industries, banking resources, wholesale and retail trade facilities, transportation facilities, agricultural development, and social features should be included. The preparation of such a presentation entails considerable work in accumulating the necessary data. A careful review and a selection of the assembled data must be made to present a factual and undistorted picture not only of details, but of overall characteristics. Such data must indicate, as accurately as possible, the nature and direction of the community's growth and development.

Local Government and Agencies

The description of the agencies of local government must accurately depict the affairs and administration of the community and the surrounding area. Investors desire information on the extent and cost of all services rendered to the population by various local units of government.

Community's General Finance

A presentation must be made of general budget operations for a period of years, the current outstanding debt, the overlapping debt, and the future general debt service requirements. This presentation requires careful assembly review, and presentation of the appropriate data.

The preceding information is necessary in addition to the presentation of the data on the specific revenue project to be financed. This discussion is on the financing of a going enterprise and, of course, presents a different problem from that of the financing of a new utility. The following factors are required in financing the expansion of existing facilities.

Physical Properties

The description of the utilities' physical properties must be carefully prepared in cooperation with competent engineers who must edit the material presented to insure its accuracy and completeness. A report of this sort could fill volumes, but a concise description of the utility's important elements serves the desires of the investors. The information must be sufficiently complete to permit the investors to form proper opinions, yet it must be limited to reasonable proportions.

Financial History and Condition

The operating data of the water utility for a period of years must be presented. The income and expense trends for an extended period are needed to ascertain the utility's soundness and stability. An investor wants to see the present balance sheet position and a statement reflecting the financing to be accomplished. Also to be shown are the structure of the existing debt and the future requirements to meet principal and interest charges after the new obligations are incurred. The method of charging for the services rendered by the utility for a period of years must be presented, together with any contemplated changes in the schedule of rates and fees. Powers to enforce the collection of charges should be shown. The extent of future capital requirements and how they are to be financed are other items to be shown. The latter subject, of course, concerns not only the financial consultant, but also the engineer and the bond attorney. It will, for example, be necessary for the engineer to present his views of future growth and the problems that it will entail.

The New Obligation

The trust indenture, or ordinance, under which the revenue bonds are to be issued must be completed before the description of the new obligation is presented to the investor. That document must be drawn by the attorney, acting as bond counsel, in collaboration with the financial consultant, who must advise the attorney of the nature of the provisions to be incorporated. The indenture will include: [1] a definition of terms used; [2] a description of the particular bonds and the manner in which they are to be issued; [3] provisions for issuing and delivering additional bonds; [4] provisions for the redemption of the bonds prior to maturity; [5] directions for application of the bond proceeds; [6] provisions for revenue application with a description of each particular fund into which revenue is distributed; [7] covenants made to the bondholder, including covenants to maintain adequate charges, to provide adequate maintenance, to insure the system properly, to maintain it free of encumbrances, to keep complete records, to furnish proper reports, to discontinue water service for delinquent payments, and to pay interest and principal; [8] provisions for remedies; [9] definition of trustees' powers and duties; and [10] provisions for supplemental indentures. All the provisions must be reviewed by the consultant and the bond counsel to assure achievement of the desired results.

For inclusion in the official statement, or circular, presented to the prospective purchaser, the consultant must paraphrase the more important provisions of the indenture and have the bond counsel review this material.

Carefully chosen language must be used so that the presentation cannot in any way mislead the investor or result in any misinterpretation of the actual indenture provisions.

Conclusions

The foregoing discussion is merely an outline of the duties of the consultant and of the document by which the revenue bonds are formally offered. The consultant must acquaint himself with and advise on many related matters.

Service rates and other charges made by the utilities should be studied and perhaps modified to eliminate any existing inequities in the rate structure. Sewer rate ordinances should provide for unusual situations, such as the existence of an industrial process which places an unusual burden on the sewage works, or, if sewage charges are based on the volume of water used, some provision should be made for such establishments as nurseries, which use large quantities of water that never enter the sanitary sewers. Billing and collection methods may require improvement.

A consultant may be called to testify in a litigation as an expert witness. The author has represented municipal clients in such matters as municipal bankruptcy, sales tax suits, annexation proceedings, and public toll bridge financing.

When all types of government or public agencies are being served it is difficult to forecast the problems which may arise. Times and conditions change, and new types of financing are always being developed. A surprisingly large number of services are at present being financed on a revenue or user-pay basis. Some southern cities which have recently built factories and other industrial or commercial buildings have financed these enterprises with revenue bonds secured by mortgages on the structures and by their rentals. This type of financing has caused deep concern to the author and to forthright bond attorneys who have in mind the long-range interest of their municipal clients.

Financing of essential public works through the sale of revenue bonds is not a project for amateurs. To market the securities successfully, three types of professional services are required: a recognized bond attorney to draw the proceedings and to issue the approving opinion, without which the bonds cannot be marketed; a qualified firm of consulting engineers to design and supervise the construction of the project and to obtain certain of the basic data necessary to the financing; and a competent financial consultant to design the loan, to provide the appropriate information which the investor will require, and to afford the issuing body the benefit of his experience and judgment on the many details necessary to obtain the money on the most favorable terms possible.

Antifreeze Protection for Sprinkler Systems

Unofficial Staff Report

The AWWA Board of Directors in 1950 activated a task group to consider the controls exercised over the use of antifreeze solutions in sprinkler systems connected to public water supplies. After careful investigation, the group recommended that the Association adopt no official policy on the subject. The board, in accepting the recommendations of the task group, directed that a summary statement be published that would bring to all members of the Association information concerning the procedures which had been promulgated by the National Board of Fire Underwriters and the Associated Factory Mutual Fire Insurance Companies.

NOTE: *The following is not a recommended procedure but merely a report of field practice.*

ANTIFREEZE, or nonfreezing, solutions are used for maintaining automatic wet-system sprinkler protection in small unheated areas which would otherwise be shut off and drained during freezing weather. The use of such solutions is considered acceptable practice only on systems with not more than 20 sprinkler heads, as the cost of refilling, or even replenishing, small leaks makes conversion to a dry system more advisable if more than that number of sprinkler heads must be supplied.

The universally recommended antifreeze for systems connected with the public water supply is a solution of glycerine (cp, or USP 96.5 per cent grade) and water. Although solutions of propylene glycol and water are considered acceptable by the National Fire Protection Assn., the lack of unanimity in acceptance of these solutions by health authorities has dictated their omission from other lists of recommended solutions. As all standards indicate that the use of nonfreezing solutions must conform with applicable state and local health regulations, the preference for pure glycerine solutions, which are generally known to introduce no hazards to health, is obvious.

Use of Nonfreezing Solutions

In practice, nonfreezing solutions are prepared with a freezing point a few degrees below the expected minimum temperature of the locality involved. The specific gravity of the prepared solution is checked by a small hydrometer with a suitable scale. Glycerine is never used unless it is mixed

TABLE 1

Glycerine Solution for Use in Sprinkler Systems Connected to Public Water Supply*

Water Vol. *per cent*	Sp Grt at 60°F	Freezing Point—°F
50	1.133	−15
40	1.151	−22
30	1.165	−40

* Cp or USP 96.5 per cent grade.
† Hydrometer scale 1.000–1.200.

with water in proper proportion, for, by itself, the material becomes extremely viscous at approximately 32° F. Suitable mixtures are given in Table 1.

When supply piping and valves are being arranged, a first principle is that all nonfreezing solutions are heavier than water. At the point of contact (interface) the heavier liquid must be below the lighter liquid to prevent diffusion of water into the unheated areas. In most installations, this factor makes necessary the use of a 5-ft drop pipe or U-loop of the type shown in Fig. 1. It is preferable to keep the sprinklers below the point of contact between the water and the nonfreezing solution. If sprinklers are above this point, a check valve with a $\frac{1}{32}$-in. hole in the clapper is provided in the U-loop to allow for expansion of the solution during a temperature rise and thus prevent damage to the sprinkler heads. Figure 1 shows an installation provided with a water control valve, two small solution test valves, and an acceptable arrangement of filling cup. To avoid leakage in such an installation, the materials and workmanship must be excellent, the threads must be clean and sharp, and the joints tight. Only nonferrous metal-faced valves are used.

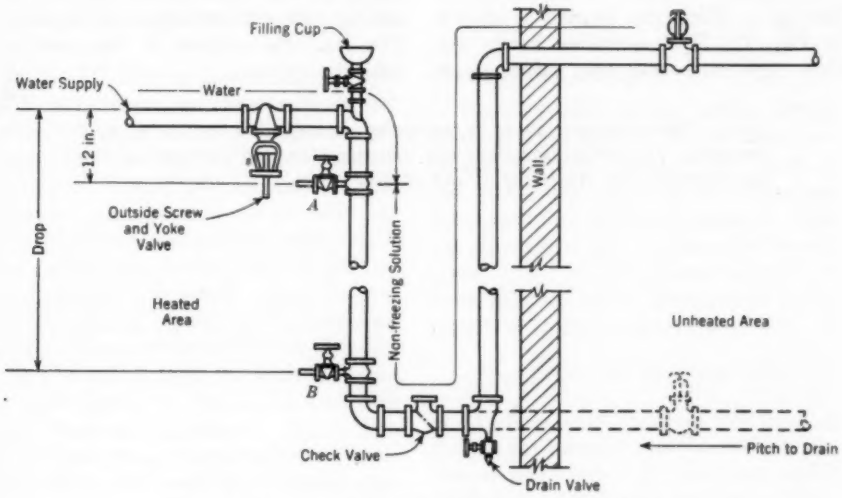

Fig. 1. Arrangement of Supply Piping and Valves

Check valve has a $\frac{1}{32}$-in. hole in clapper. Check valve may be omitted if sprinklers are below level of Valve A. *Drop must be minimum of 5 ft.*

Filling the System

To fill such a system with antifreeze, the water supply valve is closed and the system drained. Then the piping is filled through the filling cup, and the air is vented at the end sprinklers. All sprinklers should be backed out of the system until the liquid appears, to per-

mit air to escape around the threads so that the piping will be completely filled and all air expelled.

If the filling cup is not above the highest sprinklers, the piping may be filled through a valve such as *B* in Fig. 1 by means of a small pump or through a filling cup installed at the highest branch sprinkler line. When a system is filled through the branch sprinkler line, the drop pipe is filled through a filling cup located as shown in Fig. 1. The sprinkler heads are then tightened and the valve at *A* opened until the section of pipe above the valve is empty, and the level of the nonfreezing solution in the drop pipe is at the valve. After this action is completed, the valve at *A* is closed, the filling connection valve is closed, and the supply valve opened wide.

Before freezing weather each year, the solution in an entire system is emptied into convenient containers and brought to proper specific gravity by adding concentrated liquid as required. The resulting solution is then used to refill the system.

NOTE: *The summary above is presented merely as a review of field practice. Its publication does not constitute an endorsement of this procedure by the American Water Works Assn.*

Adequacy and Reliability of Water Systems in Fire Protection

By Kenneth J. Carl

A paper presented on Nov. 2, 1950, at the Chesapeake Section Meeting, Wilmington, Del., by Kenneth J Carl, Engr., National Board of Fire Underwriters, New York.

ANALYSIS of water supply systems from the standpoint of fire protection has for many years been an important function of the National Board of Fire Underwriters. These analyses are a part of the periodic fire protection surveys made in municipalities with populations of 25,000 or greater and are based upon the requirements for water supply contained in the "Standard Schedule for Grading Cities and Towns of the United States With Reference to Their Fire Defenses and Physical Conditions (1). The more important features to be considered in such analyses of water supply systems on their ability to provide proper fire protection should be of interest.

The analysis of a water supply system begins at the source and follows the water through the supply works and distribution system to the hydrants which deliver it to the fire department pumpers. Factors which must be determined are the adequacy and reliability of the system as a whole and of each unit or group of units within it. The system is considered adequate if it can deliver the maximum requirement under the usual operating conditions, and it is considered reliable if this delivery can be maintained under certain prescribed emergency conditions.

Start of the Analysis

The first step in any water supply study is to establish the maximum required delivery, which is the sum of the maximum required fire flow and the maximum daily consumption. The maximum fire flow is generally that required for the congested value,* or principal mercantile district, and is determined from the formula:

$$G = 1{,}020\ \sqrt{P}\ (1 - 0.01\ \sqrt{P})$$

in which G is the required fire flow, in gallons per minute, and P is the population, in thousands. This formula yields a value of 12,000 gpm for a population of 200,000—the maximum population for which the formula is used.

The requirement of 12,000 gpm is considered the maximum that could be effectively used in fighting a serious fire in any block, but, in larger cities, structural conditions may be such that 2,000–8,000 gpm would be needed for

* The most important business district in a city is designated as either the principal mercantile district or the congested value district. The former term is used where occupancies are almost entirely mercantile or commercial. The latter term is used where there is a considerable proportion of warehouse, manufacturing, marketing, and other similar occupancies in addition to the mercantile and commercial ones.

a second fire within the congested value or principal mercantile district. The maximum fire flow which could be required, therefore, is 20,000 gpm. Unusual conditions in certain municipalities sometimes necessitate modifications of the required fire flows as given by the formula. Such municipalities would include those that are primarily residential, located near large cities and having large populations but no commercial or industrial districts comparable to most cities of similar population. In such communities, the fire-flow requirements are reduced in accordance with the existing structural conditions.

The required fire flow should be available for 10 hr in the congested value or principal mercantile districts of cities requiring 2,500 gpm or more and from 4 to 9 hr in the smaller municipalities requiring 1,000–2,250 gpm.

Outside the congested value or principal mercantile district in all cities, the fire-flow requirements are based upon structural conditions and are usually less than in that district. Such requirements may vary from 500 gpm in sparsely built residential districts to 10,000 gpm in heavily congested industrial areas (2).

As an example, an average city of 120,000 population may be considered. The required fire flow may be computed:

$$G = 1{,}020\sqrt{120}\,(1 - 0.01\sqrt{120})$$
$$= 10{,}000 \text{ gpm } (14.4 \text{ mgd}).$$

The figure of 100 gpcd is used in the determination of the average daily consumption. Maximum consumption, if 150 per cent of the average, would be 18 mgd. The total requirement for this system for a 10-hr period would be at a 32.4-mgd rate (18 + 14.4 mgd). The peak hourly rate, which is usually 150 per cent of the maximum daily rate, would be only 27 mgd. The size of this figure indicates that fire flow is the controlling factor in the system. On the basis of the previous assumptions, fire-flow requirements would be controlling in cities of up to 225,000 population. In cities of greater populations, the peak hourly rate would be the controlling factor. Because per capita consumption generally increases with population, however, fire flow actually ceases to be controlling at approximately 200,000 population. In areas in which consumption is not metered or is unusually high, this population limit will be much lower.

Adequacy

To be considered adequate, the supply works, including any storage provided, should be capable of delivering the maximum requirement to the distribution system. If the supply is from a single source, the full requirement may be delivered directly to the distribution system, all water may be delivered to a reservoir in or near the city from which the full requirement will be available, or a combination of the two methods may be used.

In cities that employ the first method, the capacity of the pipeline or lines from the source to the distribution system would have to equal the maximum daily consumption rate plus fire flow. For the city used in the preceding illustration, this capacity would be 32.4 mgd. As the fire flow of 14.4 mgd is required for only 10 hr, this flow may be provided by a reservoir with a minimum capacity of 6 mil gal and make possible a reduction in the capacity of the supply line or lines to the maximum consumption rate of 18 mgd. The size of main or mains from the reser-

voir will depend upon its location. If the reservoir is on the supply-line side of the distribution system and receives the full delivery from the source, the main or mains extending from it will have to deliver the full required quantity of 32.4 mgd, but, if it is so located that the supply must pass into the distribution system, with only the excess over normal consumption being delivered to the reservoir, only 14.4-mgd main capacity will be necessary between the distribution system and the reservoir.

Reliability

Although the supply works may be capable of delivering the required quantities under normal operating conditions, certain conditions, emergencies, or accidents can occur that may interrupt the supply or reduce the quantities available to the distribution system. An extended period of abnormally inadequate rainfall is a common cause for failure or reduction of supply. Reliability of the supply source may also be adversely affected by recession of the ground water table or increasing salinity in well supplies.

The critical condition of many municipal supplies during 1949 and the early part of 1950 is still fresh in the minds of most water supply engineers. Such situations can usually be anticipated in time to develop new sources or emergency supplies before complete failure or serious reduction occurs. In a large eastern city with more than 300,000 population, the average daily consumption several years ago exceeded the minimum safe yield of the gravity supply, but, until the recent reduction in rainfall, the actual yield continued to exceed average consumption. A new supply is being developed, but it probably will not be in service before the existing supply has been so greatly reduced that it will no longer deliver sufficient quantities by gravity. The city has, however, installed a temporary pumping station at the impounding reservoir and this station can deliver water from the lower portion of the reservoir until the new plant is available. Although such situations can usually be corrected in time, a careful analysis should be made to determine the possibilities of their occurrence.

Floods

Most reductions or interruptions in a normally adequate supply are the results of emergencies or accidents. The flooding of purification works or pumping stations by river waters has frequently prevented the operation of all or a part of such facilities. During the 1936 flood, both the filtration plant and the adjoining main pumping station in one New England city of 85,000 population were put out of service for approximately ten days. This city had an average consumption of 4.4 and a maximum of 6.5 mgd. Through emergency connections, some water was obtained from three small adjacent towns, but the principal reason for the maintenance of a satisfactory supply during the emergency was the existence of a 40-mil gal reservoir at high elevation within the city. This incident not only shows that a serious emergency can put a plant out of service for more than a week but also illustrates the great value of large storage within the city.

In a southwestern city of 277,000 population, a 10-in. rain during the spring of 1949 swelled the nearby river, which broke its levees in several places and flooded the main pumping station and filtration plant. The plant and all the pumps were put out of service, and

only approximately 10 mil gal of elevated storage was available. As the average consumption was 26 mgd and the maximum 48.7 mgd, a very serious condition existed. After 19 hr, an old 8-mgd reserve steam pump was started, but it had to be shut down several times because of operational difficulties. Even while it was operating, however, pressures in the congested value district were almost at zero so that no water was available from the system for fire protection, and very little was available for any other purpose. Emergencies due to storms and floods are common in many sections of the country, and the possibility of damage to supply works should be given careful study.

Breaks and Repairs

The discussion on the reliability of supply works has thus far been concerned with adverse conditions which result from natural causes, but each year numerous breaks in mains or necessary repair work cause curtailment of supply. The standard schedule for grading cities (1) requires that, with the most serious break possible, the system should be able to deliver sufficient water for a 10-hr fire at some time during a five-day period of maximum consumption.

In the example of a city of 120,000 population previously mentioned, the maximum consumption of 18 mgd must be available for five days, and, during that time, must be available to fight a 10-hr fire. If no storage is provided and there are two supply lines capable of delivering 17 mgd each, a break in one line will leave only 17 mgd to meet a requirement of 32.4 mgd. If there is a single line of 32.4-mgd capacity, a break completely cuts off the city's supply. The requirements could be met by two lines, each with a capacity of 18 mgd (the maximum daily consumption) and a storage reservoir in the city with a capacity of 6 mil gal. If one line were out of service, the other one could supply maximum consumption for an indefinite period, and the reservoir could supply water for the 10-hr. fire.

A recent break in the supply line of a New England city of 40,000 population illustrates the danger of too great dependence upon a single main. The supply is delivered through a 30-in. line approximately 7 miles long, terminating at the city pumping station. The water is pumped from the station to a distribution system that has no storage. In the spring of 1949, a break occurred in the 30-in. line and cut off all supply except that available from a small reserve infiltration basin near the pumping station. The average consumption is 3.3 mgd; the maximum is 5.6 mgd. As soon as the break was detected, operations were changed so that two of the three pumps could take suction from the basin. The rate available, however, was only approximately 1.5 mgd. To deliver an emergency supply from a large state institution a mile away, five fire department pumpers—four of them loaned by adjoining communities, were connected in series by hose lines. These pumpers began pumping approximately 16 hr after the break occurred and continued for 22 hr, delivering approximately 600 gpm until the break was repaired and normal service restored. The fire flow requirement for this city is 6,000 gpm, but, during the 38 hr that the main was broken, not even the average daily consumption rate was available. If a serious fire had occurred during that period, a conflagration could have de-

veloped, as the fire department would not have had enough water to fight anything but a minor fire.

Pumping Requirements

Many municipalities obtain their supplies from sources which require pumping. Thus, the adequacy and reliability of the pumping stations are important parts of the analysis. To be considered adequate, the pumping capacity must deliver the maximum daily consumption and fire flow, as previously discussed. Various combinations of pumping capacity and storage are possible to meet this requirement.

In an analysis of reliability, the effect of removing the largest and second largest pump from service is studied. To be considered reliable, the system must deliver, without use of the two largest pumps, maximum consumption for a five-day period and fire flow for a 10-hr fire. Provision of sufficient storage to furnish the fire flow will reduce the required capacity of the pumps and provide better operating conditions. Any additional storage further increases the reliability of the system. In some cities, additional storage that will supply one or more days of maximum consumption is provided. The city previously mentioned that has a 40-mil gal reservoir and a maximum consumption of 6,500,000 gpd can supply maximum consumption directly from storage for five days and still have 7.5 mil gal for fire protection purposes. The required fire flow in this particular city is 8,000 gpm, or 11.5 mgd, so that only 4.8 mil gal would be required for a 10-hr fire.

Types of Pump Failure

A report received from the superintendent of a southeastern city of 40,000 population illustrates the various types of pump and main failure that can occur in a system within a short time. The average consumption in the system, which also supplies about 20,000 persons beyond the city limits, is 7.3 mgd, and the maximum is 9.6 mgd. The supply is obtained from an impounding reservoir and pumped to the distribution system through two supply lines. Two 3-mil gal reservoirs float on the supply lines to the city and a 1.5-mil gal elevated tank is within the city.

In the fall of 1948, the circuit breaker on the 9-mgd pump, the largest of the four provided, failed, and delays in obtaining repair parts kept it out of service for two months. One month after the failure, the second largest pump, of 5-mil gal capacity, was out of service for 3 hr. A week later, because of short circuits, it was again out for 12 hr. These failures made it necessary for the two small pumps, each of 4-mgd capacity, to carry the load.

A week after the largest pump had been returned to service, a leak that developed in one of the suction lines prevented delivery for more than two days to all except the 5-mgd pump. While the suction line was being repaired, a leak occurred in a joint of the larger supply line necessitating a shutdown of that line for 14 hr. During the period when only the 5-mgd pump was in service, and the system could not even have delivered average daily consumption plus the 6,000-gpm fire flow required for a 10-hr fire before exhausting the existing storage. In such situations, it is good practice to hold enough storage in the reservoirs or tanks provided to supply the requirements for a possible, serious fire.

Other Reliability Features

When a break occurs within a pumping station, large quantities of water

may be discharged, and every precaution should be taken to reduce to a minimum the effects of such a discharge on station equipment. The volume of discharged water can be reduced by installing check valves on discharge lines just outside the station. If the possibility of heavy discharge cannot be eliminated, adequate gravity drainage or sufficiently large sump pumps should be provided. The station should be of a noncombustible construction and free of exposures. All electrical, steam, oil, gas, and heating equipment should be safely installed.

The power supply for the main pumping equipment should be capable of operating sufficient units to enable delivery of the maximum daily consumption and fire flow. In the event of a break in an electric power circuit, a steam, gas, gasoline, or oil line, or of the failure of a switch, transformer, valve, boiler-feed supply, oil pump, or similar equipment, the fire flow for the ten-hour period should be available during a period of two days of maximum consumption. The reliability requirements for this type of equipment are not as great as those for supply mains and pumping capacity. Actual experiences indicate that this difference is justified.

Purification Works

In systems in which the water must be treated, it is necessary to analyze the purification works. To meet the maximum consumption and fire flow, an overload of 25 per cent is permitted in determining filter capacity. The effect on reliability of the removal of one filter unit normally available should be considered. All parts of the purification works should be studied—particularly the piping, a break in which will often be the most serious in the entire system.

A common fault with purification plants is the lack of sufficient clear-water storage. Such storage is very important as it enables the plant to operate at more uniform rates, but it may also be important in providing a part or all of the storage required for fire flow.

Fire Flow

The distribution system must deliver adequate quantities for consumption and fire protection to all portions of the area supplied and have a reasonable degree of reliability in providing water during breaks or accidents within the system. Fire-flow tests are made to determine the actual quantities which are available, and the results of these tests are used in conjunction with other data and records to analyze the system.

For adequate supply and reasonable reliability in the average distribution system, secondary feeders of at least 12-in. diam should extend from the main arteries at approximately 3,000-ft intervals and form loops; no important areas should be dependent on single mains. For many years, 6-in. mains have been recognized as the minimum size for supplying hydrants, and some cities now use none smaller than 8-in. If 6-in. mains are used, they should be cross-connected in the gridiron at intervals not exceeding 600 ft. If 8-in. or larger cross-connecting mains are used and the pressure is sufficient, the interval may be somewhat increased. In high-value districts, the minimum size should be 8-in., with 12-in. or larger mains on all principal streets.

Gate Valves

The reliability of the distribution system depends greatly upon the number and location of the gate valves provided. Valves in the gridiron should be installed so that not more than 500 ft of mains in high-value districts nor more than 800 ft of mains in residential areas would have to be shut down because of any single break. On mains of the arterial system, valves should be installed at quarter-mile intervals. To make certain that all valves will operate satisfactorily during an emergency, and that they are not preventing the full capacity of the system from being utilized because they are completely or partially closed, regular annual inspections are necessary. For the important valves, more frequent inspection is advised.

In the spring of 1949, in a midwestern city of 64,000 population, it was necessary to shut down a 30-in. main, one of the two main arteries of the distribution system. The remaining 24-in. main was considered capable of furnishing at least a fair supply while the repairs were under way. When the shutdown was made, a serious water shortage developed, and an investigation disclosed that a valve on the 24-in. main was closed. Fortunately, this condition was found and remedied, but the incident convinced the city officials that annual inspections were necessary. If closed valves exist, the full benefits of the investment made in the distribution system are not being obtained, and sometimes serious reductions in potential fire protection result.

References

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Investigation of Underground Structures in the Milwaukee Distribution System

By Ervin C. Weickert

A paper presented on Sept. 27, 1951, at the Wisconsin Section Meeting, Milwaukee, Wis., by Ervin C. Weickert, Civ. Engr., Water Works Construction Div., Milwaukee, Wis.

THE first water mains in the Milwaukee system were laid in 1872 from the North Point Pumping Station on the lake shore to service areas in the downtown section of the city. The first large mains were extended to the central downtown area. This underground system was subsequently extended, and by January 1, 1942, it included 1,100 miles of mains.

It is generally accepted that approximately 60 per cent of the value of a water works system is in its underground equipment. Because these installations are hidden from observation if no one is specifically commissioned to check on their condition, they are neglected, and the more exposed facilities receive most of the attention. Early investigations of underground structures and materials were more or less spontaneous and were not always recorded. In January 1946, an engineer in the water construction division was assigned to make a daily investigation of underground structures in the system in an effort to reduce or eliminate defective materials, faulty construction, corrosion, and other destructive forces affecting the underground system. A continuous series of investigations was undertaken, and much information was gathered.

A knowledge of the existing water works system is necessary not only to determine its present condition, but also to protect the future of the system by eliminating existing faults and by using the most suitable materials and methods for new construction. During the present era of industrial and scientific progress much information is being made available for study and proper application. Adequate examination of the underground system is essential to protect the large capital investment and thus provide maximum economy, reduce maintenance expense, and increase the life expectancy of the entire system.

Since the start of the daily examinations in 1946, approximately 500 reports on conditions in the underground system have been written. These reports cover such subjects as the acceptability of construction materials, current condition of mains and services in the streets, causes of failure to mains or services, and damage caused by corrosion.

Some recommendations which were accepted as a direct result of these investigations are: the replacement of one stretch of water mains because of corrosive destruction; the replacement of another with special construction

treatment because of corrosive conditions; and the continuation in service of some of the water mains laid in 1872. The last area was originally swampland, and there is evidence of excessive settlement of underground structures. In view of the pipe's age, this evidence would have been ample to support a conclusion that the mains and services needed replacement. The investigation of exposed facilities, however, revealed that, although the main and services were almost 80 years old, they were in good condition and were therefore kept in service.

Investigation Objectives

The objectives of the investigation of the underground system are: determining whether the materials, method of construction, and ground conditions are conducive to long service life; determining whether economy of construction can be effected; and securing information and records upon which rehabilitation practices and a future valuation of the system can be based.

Because it is necessary to be alert to new improvements and practices in the water works field, materials testing is a part of the investigations. Tests have been made, therefore, of such items as jointing compounds, joint materials, bolting materials, and threaded-joint sealing compounds. From these tests a knowledge of a material and its application is obtained before the product is accepted for general use in the system.

Because environment and construction are of vital importance to the service life of any part of the underground system, studies are made of the effect of vibration, settlement, soil conditions, structural features, and electrolysis and other electrochemical actions. As the number of investigation records increases with time, areas in which identities of the above factors affecting service life are dominant can be more clearly defined. Reasons for failure or deterioration then become more apparent and suggested remedies are more certain of success. This information is of great value also in solving street-improvement problems and in setting future valuations of the distribution system based on the life expectancy of its integral parts.

Investigation Method

The procedure followed in the investigation consists in visiting locations at which either new construction or repair work is being performed and observing exposed existing mains and services. Any failure, defect, or deterioration is carefully examined to determine its cause and to observe any condition affecting life expectancy. If corrosion indicates possible electrical action, electrical tests are sometimes made to determine whether the cause is electrolysis, galvanic action, or other destructive electrochemical action.

Notes are kept on soil and ground conditions. Pertinent information is obtained, and reports of the most important or unusual investigations are written. These reports are sent to the proper persons, and copies and field notes are filed and indexed for future reference.

A quarter-section (0.25 square mile) atlas of the entire water-main system is used as a reference index to show locations in which failures or deterioration of mains or services has occurred and to show the dates of the investigation.

The investigation of underground facilities is divided into three parts:

[1] the outside, or field, investigation; [2] the inside, or office, investigation; and [3] the recording of pertinent data and reports.

Field Investigation

The water department prepares a daily work schedule sheet, which provides a list of sites at which contractors' construction crews or water department distribution crews are working. From this list, the engineer selects for investigation those sites which are known or suspected to be trouble areas. Office records are checked to determine the date of installation of the exposed mains, services, or structures, and the engineer visits the site. General observations are made of the site location, date, weather conditions, reason for the excavation (repair, alteration, construction, or any other), and the identity of the contractor or repair crews engaged in the work. If a failure has occurred in the exposed facilities, an inspection is made, and the details are recorded. Ground conditions, both surface and subsurface, are also observed. A field sketch is often made to show the size of the excavation and the location of all exposed mains and structures. Soil conditions that are noted include: type, color, texture, compactness, and moisture content, and whether it is original soil, filled ground, or backfill.

After general observations are noted, an examination of the exposed facilities is made. Pertinent data are gathered to establish the present condition and probable service life or the cause of failure, if that is the reason for the investigation.

If a failure in a cast-iron water main or branch service line is being investigated, the observations are keyed to determining the cause of the failure. Joint leaks, corrosion, or broken pipe and fittings are responsible for most failures in cast-iron lines. Possible causes of a lead-joint failure which are studied are: displacement of the lead, faulty material or workmanship, excessive pressures and water hammer, vibration, settlement, contact with other structures, frost, and inadequate support.

If lead-jointed mains show evidence of corrosion, electrical tests are sometimes advisable to establish the cause of the destruction. Such tests include: [1] measurement of the difference in potential between the water main and other utility facilities or the earth; and

TABLE 1

Investigations Made Between January 1946 and December 1951

Reason for Investigation	No. of Investigations	Special Reports
Failure from defective material or workmanship	119	0
Failure from settlement	79	0
Sulfur-compound joints	67	8
Failure from electrolysis	59	5
Failure from excessive pressure	56	1
Failure from vibration	46	0
Undetermined or other	36	17
Failure from soil conditions	35	0
Failures from galvanic action	18	0
Street improvement	3	2

[2] the magnitude of the current in the main. Shepard-rod tests of soil resistivity and pH tests of acidity may also be made. When requested to do so, the electric utility cooperates with the city in conducting such electrical tests.

If failures occur in mains jointed with sulfur compounds, the joints are examined for deterioration. After the joint is removed, the pipe is examined closely for evidence of pitting. Moisture conditions, both past and current, are an important factor in the failure of sulfur-jointed mains, and all available information is obtained. If elec-

troylsis is indicated or suspected, electrical tests are made to determine the resistance of the sulfur-compound joints to electrical currents.

If failures in cast-iron lines are due to broken pipe or fittings, possible causes investigated are: contact with other structures, frozen ground conditions, and physical defects in the pipe or fittings. A detailed inspection is made to determine whether the broken pieces conform to specifications. Lead-pipe service-line failures may be caused by breaks in the soldered joint, rupture of the pipe by internal pressures, weakened pipe from inclusions in the lead, or failure of the corporation or curb stop. Copper-pipe service lines may fail in the corporation or curb stop, or in the threaded brass couplings. They may also fail because no offset is provided in the copper pipe for slack. No failures have been experienced in copper services because of internal pressures. An investigation of these possible causes for failure of a lead or copper service line usually discloses the reason.

Gate valves and hydrants may also cause pipeline failures. Mechanical defects, leaks through the stuffing-box packing, corrosion of bonnet and stuffing-box bolts, and broken castings can contribute to such failures.

Through normal construction and maintenance practices, numerous opportunities are made available to observe the condition of the underground distribution system. In the field investigation, use is made of these opportunities to obtain factual information.

Office Investigation

To obtain related information, the field investigation is supplemented by an examination of office records. Adjacent underground structures are located, pressure conditions in the mains are studied, and reports and field records of similar investigations in the area are analyzed for possible factors contributing to the failures being studied. Through the field investigation and the related office and field records, both current and past ones, the cause of the failure or damage is usually determined.

If the pipe is corroded, an estimate is made of its life expectancy. This estimate is based upon the formula:

$$\text{Probable life} = \frac{TY}{P}$$

in which T is the thickness of pipe, in inches; P is the penetration of corrosion, in inches; and Y is the number of years during which the pipe has been in service.

Records

The collection of field and office data is of little value unless they are systematically correlated and recorded to render the information readily available for reference. Reports are written to cover each investigation. Those which are of immediate importance are prepared first; they are followed by those having future significance and then by those in which unusual conditions are present. These investigations are generally classified according to their subject matter as shown in Table 1.

A quarter-section atlas showing the water distribution system is used as an index of the investigations. Each investigation is located on the proper quarter-section map with a notation of the date and number of the report. The general subject category which applies to the particular investigation

is designated by a characteristic mark. Thus, a glance at the quarter-section map will immediately reveal the location of all investigations made in a specific area, the dates and numbers of the reports on them, and the cause of failure or other reasons for the investigation. If detailed information is desired, it can be obtained from the individual reports and records, which are filed according to the numbers and dates in the atlas.

Conclusions

Efforts must be maintained to eliminate faults, failures, and deterioration in any part of the water system while these conditions continue to exist or develop. Only with adequate investigations and records of the past performance of underground systems can reasonably accurate estimates be made of their present conditions and values, and only by eliminating the causes of past difficulties can efficiency and economy be maintained in replacing mains and services or in future construction. Accurate knowledge of existing faults in the underground system and of their location permits more precise determination of their causes and their eventual elimination or correction—possibly by the use of new materials or construction methods.

The accumulated knowledge of the condition of the underground structures increases in value each year, and it is particularly useful when preparing the yearly street-improvement program. If records of investigations of the condition of the underground structures showing ground conditions, faults of construction or workmanship, deterioration by corrosive actions, reasons for failure, and other information observed for a period of years, are combined with the card record of repairs maintained by the distribution division, the complete information is valuable in determining the present condition of mains and services, and the extent to which they should be repaired or replaced before new paving is laid. Investigation of the conditions of underground structures will also be of great value in preparing a valuation of the distribution system when the accumulation of records become sufficiently comprehensive to base estimates of life expectancy upon prevailing conditions over more extensive areas of investigation.

Testing and Repairing Small Water Meters

By Oscar G. Goldman

A paper presented on Oct. 25, 1951, at the California Section Meeting, San Francisco, Calif., by Oscar G. Goldman, Supt., City Distribution, San Francisco Water Dept., San Francisco, Calif.

THE San Francisco Water Dept. has written exacting specifications that require the various meter manufacturers to provide it with carefully designed and carefully manufactured instruments. The maximum head loss for various flow rates through meters of different sizes is specified. The allowable efficiency variation for the meters of different size at various flow rates is also specified.

Thus, some special type of equipment is required in the testing laboratory to check the meters. For proper testing, flow rates must be accurately measured, head loss carefully determined, water temperature known, the actual volume of water which passes through the meter ascertained, and the meter reading noted for the known volume of water passing through it.

Necessary Determinations

To determine the flow rate, the time required for a predetermined volume to pass through the meter must be known. Head loss is a function of the flow rate. All the above basic requirements, therefore, can be determined simultaneously—volume, head loss, and time.

The volume can be ascertained with calibrated tanks. A 10-cu ft tank is used for the largest volumes and a 1-cu ft tank for the smaller ones. The flow rates can be determined if the time required to fill the tank of predetermined volume is known. Head loss can be measured by installing calibrated pressure gages on the inlet and outlet sides of the meter. The time, of course, can be obtained with a watch or clock (Fig. 1).

No difficulty is encountered in measuring volume in a calibrated tank or in reading head loss on a meter by means of pressure gages, but the measurement of time is less simple. To measure the time for each and every flow with an ordinary stop watch is tedious and may be inaccurate. In the San Francisco Water Dept. Testing Laboratory, an ordinary electric clock with a sweep second hand is used. On the discharge side of the meter is installed a gate valve that may be opened and closed quickly. Special handles of steel tubing were made for the quick-opening valve. Inside the handle is a mercury switch connected to the electric clock so that, when the valve is closed, the clock is stopped; when open, the clock operates. Every rate of flow through the meter is thus determined. The timing is automatic, extremely accurate, and requires no special effort by the operator. A push-button switch permits setting of the clock at any desired position.

Flow Rate Adjustment

To adjust the flow rate through the meter, a manually operated gate or needle valve is installed in the discharge

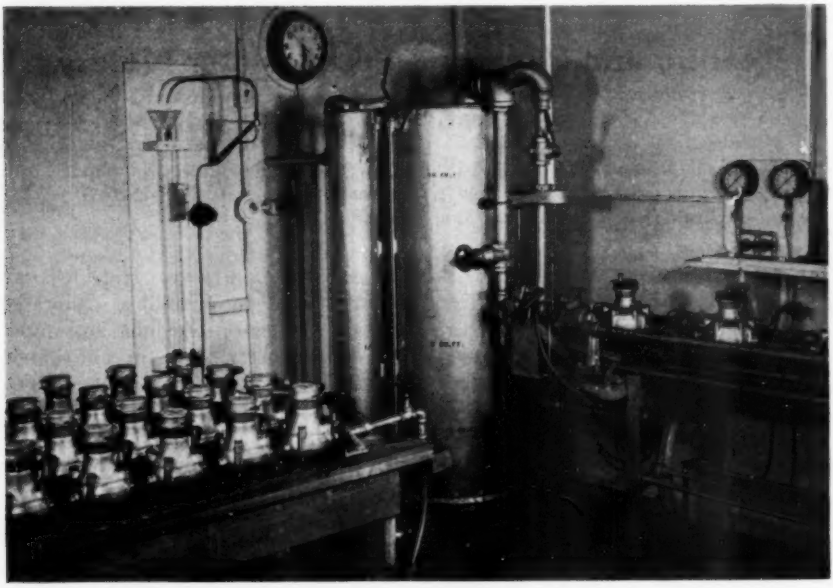

Fig. 1. Section of Testing Laboratory

This view of the testing laboratory shows a measuring tank and standard electric clock, modified to perform as a stop watch.

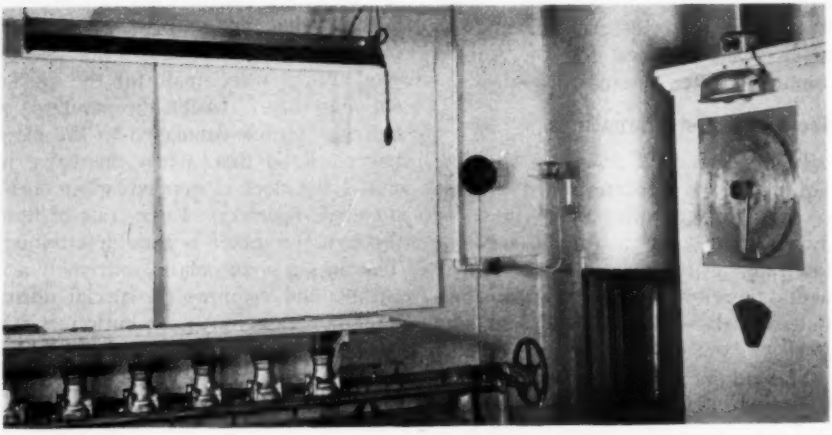

Fig. 2. Section of Testing Laboratory

The temperature gage is at the center. The surge chamber and change-gear slide rule are at right.

line from the meter between the calibrated tank and the quick-opening valve.

Flow rates at which meters of various sizes are tested are given in Table 1. The operator is also furnished with the information on filling time contained in Table 2.

As the operation of a meter is affected by the water temperature, particularly when it is more than 80°F, an indicating thermometer is installed on the inlet side of the meter, close to the main shutoff valve.

number of teeth per gear was calibrated on a logarithmic scale and correlated with the relative efficiencies. The required change gears for each meter are determined at the high rate of flow at which the meter is tested.

Meter Testing

The number of meters tested in series at various flow rates is given in Table 3. Use of laboratory equipment enables the testing, with necessary accuracy, of any meter. Any meter that fails to meet the required tests is rejected. No meter, new or repaired, is installed without laboratory testing. If meters that fail to pass the tests are new, they are returned to the manufacturer for replacement; if they are repaired meters, they are returned to the repair shop. Very few new meters have been found unsatisfactory, although occasionally one fails to meet the specified tests. Usually, such meters can be brought up to standard by a recleaning.

TABLE 1

Flow Rates and Efficiencies

Meter Size *in.*	Low-Flow Test		Intermediate-Flow Test		High-Flow Test	
	Flow* *gpm*	Min. Registration *per cent*	Flow* *gpm*	Max. Registration *per cent*	Flow† *gpm*	Min. Registration *per cent*
$\frac{5}{8}$	$\frac{1}{4}$	95.0	$1\frac{1}{2}$	101.5	15	99.0
$\frac{3}{4}$	$\frac{1}{2}$	95.0	$2\frac{3}{4}$	101.5	24	99.0
1	$\frac{3}{4}$	95.0	$3\frac{3}{4}$	101.5	41	99.0
$1\frac{1}{2}$	$1\frac{1}{2}$	95.0	8	101.5	60	99.0
2	2	95.0	15	101.5	110	99.0

* Allowable variation in flow rates is 10 per cent below the nominal rate.
† Pressure loss shall not exceed 5 psi.

Meter casings can be broken, disk plates cracked, and pressure gages damaged by a sudden rise or fall of the pressure in the supply pipeline. When quick-opening or -closing valves are used, pressure fluctuations, particularly with larger flows, increase greatly. To overcome these conditions, a properly designed, closed surge chamber was installed on the inlet side of the meters, as shown in Fig. 2.

An annoying problem in any meter testing laboratory is the securing of a quick and accurate means for determining the proper change gears to be used after the first preliminary test of repaired meters. A circular slide rule was constructed for this purpose. The

The high degree of control and accuracy to which meter testing was developed indicated that the meter-repair method formerly used was faulty. Repaired meters were reported as failing for such reasons as: excessive head

loss at specified flow rates, inability to maintain meter efficiency within specification limits, and complete failure to operate at the specified minimum flow rate.

Old Repair Method

The previous meter repair procedure required the following steps:

1. The disk assembly was placed in the chamber, and, with the aid of a grinding compound, the seats in the chamber were polished and ground to fit. The amount of grinding depended upon the clearance that was estimated to suffice between the chamber seats and the disk-assembly balls.

TABLE 2

Filling Time for Calibrated Tanks

Flow Rate *gpm*	Filling Time			
	1-cu ft Tank		10-cu ft Tank	
	min	*sec*	*min*	*sec*
¼	30	0	—	—
½	15	0	—	—
¾	10	0	—	—
1½	5	0	—	—
2	3	45	—	—
2¾	2	44	—	—
3¾	2	0	—	—
8	0	56	9	20
15	—	—	5	0
24	—	—	3	8
41	—	—	1	50
60	—	—	1	15
110	—	—	0	41

2. Paper shims were placed between the disk plate and half-ball, with no provision for the maximum number of shims. Thicker shims were incorrectly placed on the bottom side of the disk plate.

3. Mere visual inspection determined the need of replacing any meter part.

4. To determine the freedom of motion of the assembled meter, the repairman would place the inlet side of the meter to his lips and blow. If little blowing was required—and the individual's breath capacity was an important variable—the meter was considered satisfactory.

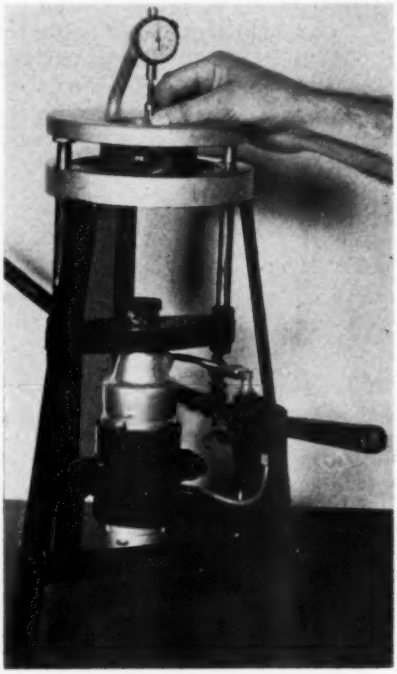

Fig. 3. Device for Measuring Clearance

The instrument measures the clearance between chamber seats and the disk assembly. The indicator is placed in contact with the disk spindle while the chamber is under mechanical pressure.

If the performance of a repaired meter is to equal that of a new one, such a repair method is obviously inadequate. To determine what procedure was necessary, meticulous study of the

construction of new meters was required.

A careful inspection of new meters indicated that all tolerances were to thousandths of an inch. Micrometers could be used, but their use demands great skill and experience. This condition necessitated the development of a simple measuring device that a relatively inexperienced man could handle with little practice, and that would meet the prescribed accuracy requirements.

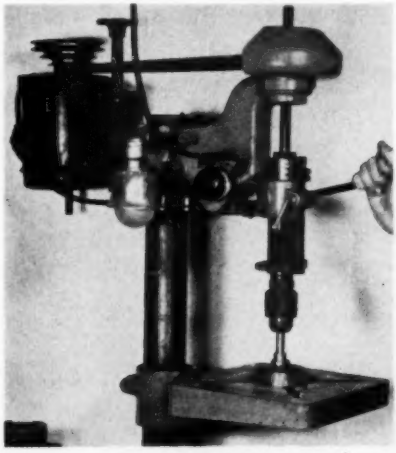

Fig. 4. Polishing Tool

This special tool, designed to polish chamber seats, is used with emery paper.

Dial indicators, in conjunction with specially designed instruments, were therefore employed.

Meter Specifications

By actual measurements, and in consultation with the various meter manufacturers, a number of specifications were established:

1. The clearance between the chamber seats and disk assembly should be that given in Table 4.

2. The clearance between the disk balls and chamber diaphragm for meters of various sizes is between 0.004 and 0.006 in.

3. The clearance between the disk plate and chamber walls should be that given in Table 5.

4. The difference in diameter between the upper edge of the chamber seat and the disk ball should be 0.002–0.003 in. It should be noted, however, that the chamber seats are segments of a sphere, whereas the disk balls are slightly elliptical.

TABLE 3

Meters Tested at Various Flow Rates

Meter Size *in.*	No. of Meters in Series		
	High Test Rate	Medium Test Rate	Low Test Rate
$\frac{5}{8}$	9	9	40
$\frac{3}{4}$	7	7	8
1	5	5	6
$1\frac{1}{2}$	4	4	4
2	3	3	3

When the above information was obtained, these questions were raised:

1. What is the actual wear in the upper and lower seats in the chamber?

2. Is the outer edge of the disk plate a perfect circle, and is the disk plate perfectly flat?

3. Is the wear in the chamber seat concentric with the walls of the chamber?

4. Does any wear occur in the chamber walls?

5. At approximately minimum flow rates, what is the maximum permissible head loss in the various assembled parts of a meter?

One of the first instruments developed is shown in Fig. 3. It was used

to determine the clearance between the chamber seats and disk assembly. This measurement was taken by placing a dial indicator in contact with the disk spindle while the chamber was under mechanical pressure. By raising the disk assembly, the clearance can be read on the indicator.

Disk Balls and Chamber Seats

Maintenance of the proper shape and size relationship between the disk ball and chamber seats is a necessary element of meter construction. The old method of grinding the disk assembly in the chamber seats destroyed the proper shape relationships. The seats were ground to the same shape and size as the disk balls. This condition was overcome by simply polishing the chamber seats with the special tool shown in Fig. 4, which is used with fine emery paper. This process increases the seat depth by approximately 0.002 in.

Some meter men and manufacturers contend that maximum wear occurs in the bottom chamber seat; others say the reverse. The device shown in Fig. 5 measures the wear in the chamber seats, and a dial indicates the measurements. This instrument proved that the maximum wear almost always occurs in the upper seat. Half-balls of different diameters, therefore, are required in the disk assembly to keep the disk plate in the center of the measuring chamber. Unless the half-balls are of large diameter, shimming them in the disk assembly has been entirely eliminated. Never should the difference in diameter between the half-balls in any disc assembly be greater than

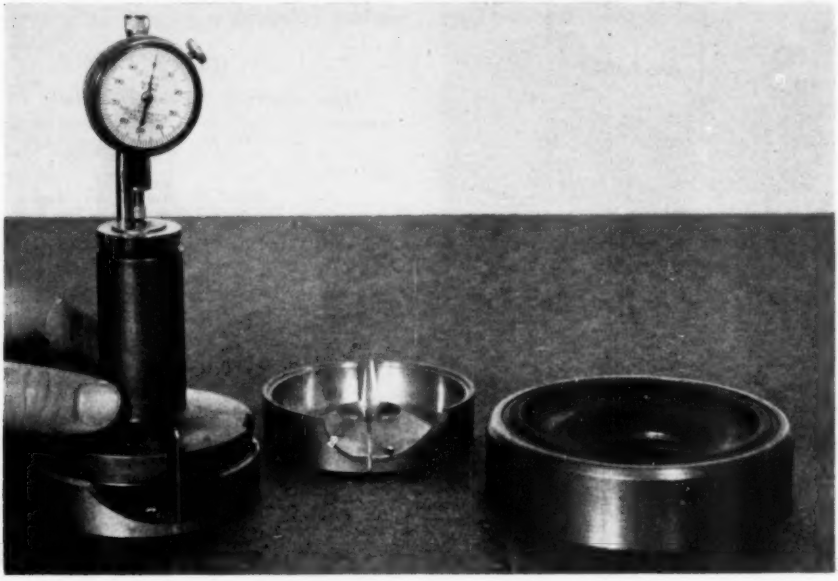

Fig. 5. Wear Gage

The dial indicates amount of wear in chamber seats.

TABLE 4

Clearance Between Chamber Seats and Disk Assembly

Meter Size *in.*	Clearance—*in.*	
	Min.	Max.
$\frac{5}{8}$	0.004	0.006
$\frac{3}{4}$	0.004	0.006
1	0.004	0.006
$1\frac{1}{2}$	0.006	0.008
2	0.006	0.008

0.004 in., however, for the proper clearance between the half-balls and measuring-chamber diaphragm cannot then be maintained.

Measurement of the Chamber

Proper meter repair requires careful checking of the measuring chamber itself to determine whether the chamber is out of round, the seat wear eccentric with the chamber walls, or the chamber walls worn. This necessity led to the development of the instrument shown in Fig. 6. As with the other instruments, a dial indicates the readings.

In a few of the oldest meters, the chamber was found to be out of round. In a few old meters in which the thrust roller or thrust-roller slot was badly worn and the disk-plate slot was so constructed that it did not bear on the chamber diaphragm, the sides of the chamber were also badly worn. In one make of meter, now practically obsolete, lack of a thrust roller caused the disk plate to bear against the diaphragm, thus badly wearing the sides of the chamber wall. None of the chamber seats were found to be eccentric with the chamber wall.

TABLE 5

Clearance Between Disk Plate and Chamber Walls

Meter Size *in.*	Clearance *in.*
$\frac{5}{8}$	0.0025
$\frac{3}{4}$	0.0025
1	0.0025
$1\frac{1}{2}$	0.0050
2	0.0050

Disk Plate and Assembly

An instrument was developed to check the disk plate and its assembly. This device, shown in Fig. 7, determined the accuracy of the disk-plate diameter and the correctness of the disk assembly.

The instrument disclosed that some disk plates became so greatly enlarged adjacent to the disk-plate slot that they caused the meters to be totally inoperative at minimum flows. A few disk plates were shown to be slightly warped, which condition also interfered with accuracy at minimum flows. No half-balls, however, were found to be eccentric to disk plates.

Sometimes the disk assembly itself gave trouble. To obtain proper clearance between the disk assembly and chamber seats, and, at the same time, to keep the disk plate at the center of the chamber, the assembled disk was made up with half balls of various diameters. Although the size of the half-balls was marked on them by the manufacturer, it was soon discovered that many markings were wrong. An instrument was required, therefore, to give accurate measurement of the half-balls. This instrument, shown in Fig. 8, has the usual dial indicator, and can also be used to measure the overall diameter of the assembled disk. It should be stated that, when the manufacturer's attention was called to this difficulty, the required corrections were made.

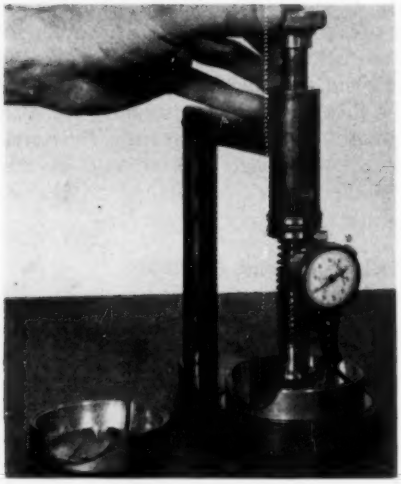

Fig. 6. Wear Gage

The dial of this particular gage indicates the amount of wear that takes place in the chamber walls.

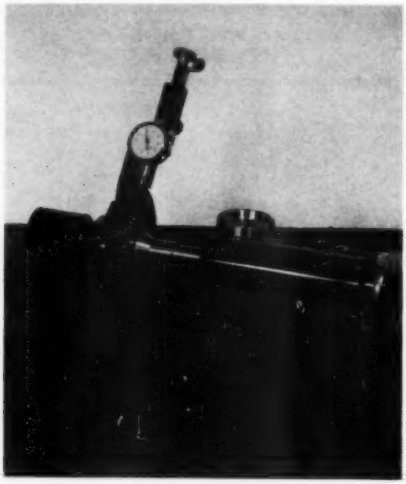

Fig. 7. Disk Assembly Gage

This instrument measures the accuracy of disk plate diameter and correctness of disk assembly.

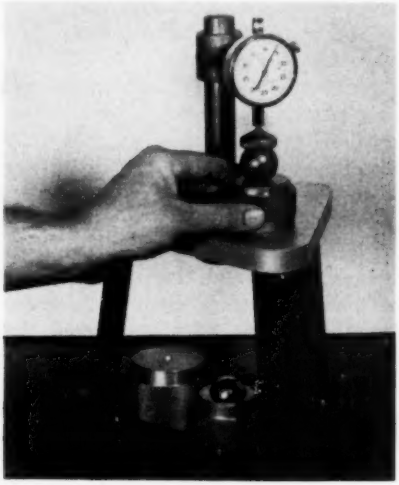

Fig. 8. Ball Gage

The dial indicates the size of half-balls. It can also measure the diameter of assembled disk.

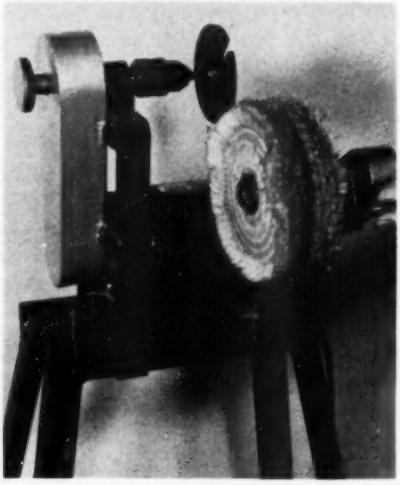

Fig. 9. Disk Assembly Polisher

The unit polishes the disk plate assembly with a segmented cloth wheel and fine chalk.

TABLE 6

Chamber Assembly Head Loss

Chamber Size in.	Head Loss in.	Orifice Diam. in.
$\frac{5}{8}$ (Style 2)	3.0	$\frac{1}{16}$
$\frac{5}{8}$ (Style 3)	2.5	$\frac{1}{16}$
$\frac{3}{4}$	2.0	$\frac{1}{16}$
$\frac{3}{4}$ (Style 4)	2.0	$\frac{1}{16}$
1	2.5	$\frac{3}{32}$
$1\frac{1}{2}$	2.5	$\frac{3}{16}$
2	4.5	$\frac{3}{16}$

Careful examination of the disk plate assembly revealed tiny particles of grit or dust, which adhere to surfaces and cause considerable friction in chamber seats. To remove these particles a tool was developed to polish the disk-plate assembly with a segmented cloth wheel and fine chalk (Fig. 9).

Because the number of faulty chambers or disk plates is extremely small, a check of all chambers and disk plates is unnecessary. This check should be used only when a repaired meter fails. To assemble a meter and give it all the required tests and then discover that it fails is, however, a waste of time and effort. This problem was overcome by first measuring the head loss in the complete chamber assembly under the same conditions as when it is installed in a meter. To make this measurement, a skeleton head was made to keep the disk spindle in its proper position and to transmit the proper pressure to the chamber assembly. To activate the disk assembly in the chamber, compressed air is used. A manometer measured the air pressure required to move the disk assembly at approximately the minimum flow rate. With carbon tetrachloride in the manometer tube (Fig. 10), the average maximum head loss of the chamber assembly is that given in Table 6.

TABLE 7

Maximum Permissible Head Loss in Assembled Meter

Meter Size in.	Head Loss in.	Orifice Diam. in.
$\frac{5}{8}$ (Style 2)	7.0	$\frac{1}{16}$
$\frac{5}{8}$ (Style 3)	5.5	$\frac{1}{16}$
$\frac{3}{4}$	4.0	$\frac{1}{16}$
$\frac{3}{4}$ (Style 4)	3.0	$\frac{1}{16}$
1	3.0	$\frac{3}{32}$
$1\frac{1}{2}$	2.5	$\frac{3}{16}$
2	4.5	$\frac{3}{16}$

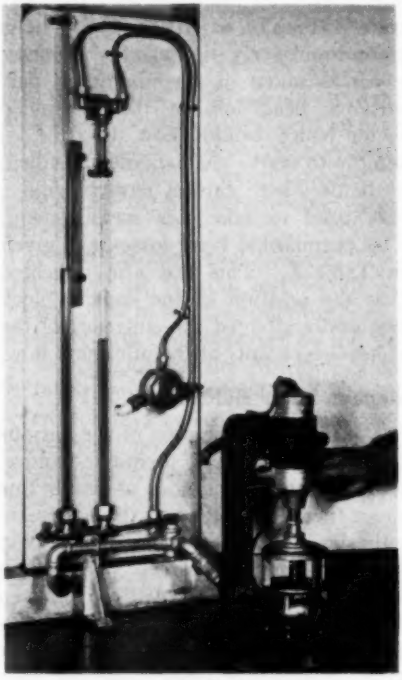

Fig. 10. Head Loss Gage

The gage measures air pressure required at approximate minimum flow to move disk assembly. The manometer tube is filled with carbon tetrachloride.

Failure of Assembled Meters

Although the chamber assembly passed the head-loss test, the completely assembled meter sometimes failed when tested at the minimum flows. Inspection disclosed that the trouble was caused by one or more of the following conditions: [1] the packing-gland nut was drawn up too tight, [2] the gear train was faulty, or [3] the casing bolts were improperly tightened. A measure was taken of the maximum permissible head loss of the assembled meter which would allow the disk assembly to start. A manometer—filled, as before, with carbon tetrachloride—was used to take this measurement. The permissible head losses are given in Table 7. This test also indicated that the position of the control block materially affected the efficiency of the meter—especially at the minimum flow.

Repair Shop Efficiency

With the development of the various tools and instruments mentioned above, and with the adoption of assembly line procedure, the output of the meter repair shop has been increased more than 100 per cent. Many meter parts which were formerly discarded have been successfully reused. The concept that the performance of a repaired meter shall equal that of a new meter has been generally fulfilled.

No repaired meter, regardless of its age, is now permitted to leave the shop when its efficiency at minimum flows is less than 90 per cent. At minimum flow rates, approximately 70 per cent of the repaired meters currently exhibit better than 95 per cent efficiency, 20 per cent are 90–95 per cent efficient, and approximately 10 per cent are 85–90 per cent efficient.

Some of the meter companies have redesigned and improved their meters, but the various parts of the models are interchangeable with those of the old ones. Whether to reuse old parts that are still in good condition is a problem that is still unsolved. Several questions must be answered before this decision can be made:

1. What is the load distribution through the meter?
2. How do the load distribution and the efficiency of the meter affect the income?
3. When should meters be taken out of service for repair?

The answers to the first two questions must be based on field observation and will be determined by actual experiments with the consuming public. The answer to the third question depends upon the type and condition of the water in each particular locality. It is hoped that the answers to all of these questions will be available for San Francisco within the next year.

All of the tools and instruments used in the meter repair shop and testing laboratory were developed and built in the machine shop of the San Francisco Water Dept. Much of the development of the meter testing laboratory and repair shop was the result of a free discussion among the repairmen, machinists and the author—it is the result of the combined thinking of all.

Although much has been done to bring the efficiency of a repaired meter to that of a new one, all repaired meters do not meet this requirement. Improvements are still required in the art of meter repair.

The Economics of a Meter-Test Program

By W. L. Wardrop

A paper presented on Sept. 13, 1951, at the Minnesota Section Meeting, Minneapolis, Minn., by W. L. Wardrop, Engr., Water Works and Sewerage Branch, City Eng. Dept., Winnipeg, Man.

TO establish a basis for investigating the economic soundness of the present routine for testing ⅝-in. meters in Winnipeg, the water department made an analysis of 25 meters chosen at random from each of eight groups, classed by age in 5-yr intervals from 10 to 45 yr of age. Data on the "before-adjustment" tests and on the cost of removing, testing, and repairing each meter were collected.

The before-adjustment tests were made at rates of 10-, 1-, and ¼-gpm,* with results as shown in Table 1. Meters reported not working represented 5, 24, and 53 per cent for the respective test rates, and a plotting of the data, as shown in Fig. 1, indicates the probable average number of meters that will be "not working" after other in-service periods. The data reveal a straight-line relationship between number of meters not working and length of period in service. Although some of the meters reported not working may have become blocked by sediment in the removal operation, this possibility was not taken into account in the analysis. Approximately 19 per cent of the meters which normally are brought into the shop are removed from the system because of meter readers' reports that they are not working, and an additional 8 per cent are removed because of freezing. Average registration values were adjusted to compensate for the meters reported not working.

It was assumed that a meter inoperative on the 10-gpm test would not register flow in service and, thus, would probably have been reported by the meter reader, so that the customer could be billed on a flat-rate basis. As no revenue would be lost under such circumstances, no adjustment was made to the registration values in the 10-gpm test.

At the lower flows, of course, meters classed as not working are of the greatest significance. For the 1- and ¼-gpm tests, therefore, under-registration values were adjusted by:

1. Determining from Fig. 1 the probable average number of meters not working in each age group.

2. Assuming that the meters reported inoperative are under-registering 50 per cent and adjusting the values in Columns 5 and 8 of Table 1 accordingly.

The assumption in Step 2 is based on the operation of the Winnipeg rate schedule which includes a minimum charge of 50 cents per room per quarter with an allowance of 25 gpd per

* The unit, "gallons," throughout refers to U.S. gallons.

TABLE 1

Before-Adjustment Tests Showing Averaged Results of 25 Meters from Each Age Group

1	2	3	4	5	6	7	8	9	10
	10-gpm Test Rate			1-gpm Test Rate			¼-gpm Test Rate		
Age Group *yr*	Avgd. Under-registration *per cent*	Number Not Working	Adjusted Under-registration *per cent*	Avgd. Under-registration *per cent*	Number Not Working	Adjusted Under-registration *per cent*	Avgd. Under-registration *per cent*	Number Not Working	Adjusted Under-registration *per cent*
10	−1.0	1	−1.00	− 3.00	4	− 7.10	−31.70	5	35.20
15	−1.33	1	−1.33	− 3.12	3	− 8.75	−32.66	7	37.80
20	−2.18	2	−2.18	− 4.16	3	−11.20	−17.82	7	28.50
25	−4.13	1	−4.13	− 6.56	8	−17.80	−26.30	12	37.80
30	−5.57	1	−5.57	− 6.10	7	−18.40	−34.10	11	42.09
35	−5.60	—	−5.60	− 9.74	4	−21.00	−39.00	19	47.50
40	−6.47	3	−6.47	−11.70	7	−24.70	−23.00	23	47.40
45	−7.95	1	−7.95	−10.30	12	−27.50	—	23	48.40
TOTAL NOT WORKING		10			48			107	
PROPORTION OF TOTAL TESTED—*per cent*		5			24			53	

room plus a charge of 35 cents per 1,000 gal for all in excess of the allowance, and less a discount of 5 per cent for prompt payment. The calculation involved in Step 2 is based on the fact that approximately 30 per cent of the domestic accounts include excess charges throughout the year and that an additional 20 per cent of those accounts which closely approximate the flat rate would probably be brought within the excess range by accurate registration.

The adjusted values of the averaged under-registration for each age group given in Columns 4, 7, and 10 of Table 2 were used to plot the accuracy curves in Fig. 2. Under-registration

TABLE 2

Under-registration as Taken From Curves Plotted From Before-Adjustment Tests *

1	2	3	4	5	6	7
Age Group *yr*	Under-registration—*per cent*					
	10-gpm Test	5-gpm Test	2-gpm Test	1-gpm Test	½-gpm Test	¼-gpm Test
10	−1.0	− 4.5	− 6.5	− 7.0	−10.0	−35.0
15	−1.33	− 5.8	− 8.0	− 8.75	−13.0	−37.5
20	−2.18	− 7.5	−10.5	−11.20	−17.0	−37.8
25	−4.13	−12.0	−16.0	−17.80	−23.0	−37.8
30	−5.57	−13.0	−17.0	−18.40	−25.0	−42.0
35	−5.60	−14.0	−19.5	−21.0	−31.0	−47.5
40	−6.47	−16.7	−22.8	−24.70	−35.0	−47.4
45	−7.95	−18.7	−25.0	−27.50	−37.0	−48.4

* Values adjusted.

values for flow rates of $\frac{1}{4}$, $\frac{1}{2}$, 1, 2, 5, and 10 gpm taken from these curves are shown in Table 2.

Time did not permit an investigation of the probable average consumption rates at various flows for the Winnipeg area. The proportional rates used for this analysis (Table 3) were taken from an article by D. R. Taylor (1). With them, weighted values of under-registration were determined for each group, as shown in Column 2 of Table 4.

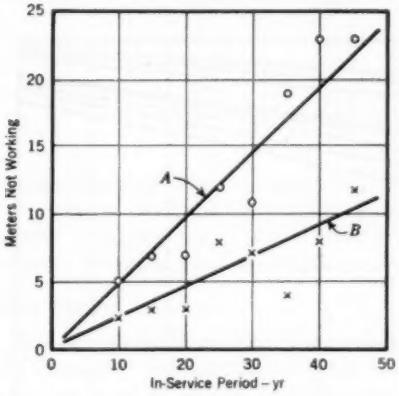

Fig. 1. Probable Average Number of Meters Not Working

Curve A shows the probable average number for the $\frac{1}{4}$-gpm test and Curve B for the 1-gpm test.

Underregistration and Revenue Loss

To determine the relation between under-registration and loss of revenue, the average consumption for a domestic unit in the Winnipeg area was assumed to be 11,375 gal per quarter, equivalent to the allowable flat-rate consumption for a five-room dwelling. All meters that show a weighted under-registration are assumed to involve a loss of revenue calculated at the domestic rate charged for excess water. This assumption is made on the basis that those accounts which show excess use throughout the year would compensate for those that are below the flat-rate limit.

With a value of 33.2 cents per 1,000 gal (discount deducted), a weighted under-registration of 1 per cent would represent an annual loss of revenue of 15.1¢. The probable annual loss of revenue per meter for each of the age groups, shown in Column 3 of Table 4, varies from $1.02 for a meter in its tenth year of service to $3.45 for a meter in its forty-fifth year of service.

TABLE 3

Consumption Rates at Various Flows

Flow Rate *gpm*	Consumption Rate *per cent*
0.25	5
0.5	6
1.0	8
2.0	31
5.0	40
10.0	10

Meters of relatively long service should obviously be removed for routine test as soon as possible.

Winnipeg still has a number of meters in service which have not been given the standard routine test. Prior to 1934, meters were repaired in the field, and no routine test program was in effect. In 1934, however, a policy of routine testing $\frac{5}{8}$-in. meters once every 7 yr was adopted. War shortages of labor and material made it impossible to carry out the program, so that the routine-test period had to be extended to at least 15 yr. In the latter part of 1949, however, when the meter section was reorganized, the rou-

tine test program for ⅝-in. meters was reviewed and placed on a 10-yr basis.

Establishment of Test Program

In the establishment of a routine test program, it must be remembered that a considerable proportion of the meters that pass through the repair shop are actually repeats which should not be considered as routine-test meters. A repeat meter should, however, be credited with an equivalent routine-test value prorated on the basis of the number of years in service within the cycle. For example, a meter that was removed 2 yr after it was installed should be given an equivalent rating of 0.2 if the routine test period is on the basis of 10 yr.

During 1950, 4,400 meters were repaired in the shop by the meter section. Of this total, only 2,600, or 5 per cent, had exceeded the 10-yr in-service period that is the present basis for the routine test program. Thus, the remaining 1,800 meters were repeats, which accounted for approximately 700 additional equivalent routine tests, bringing the total number of effective routine tests for the year to 3,300 compared with the total of 4,400 meters repaired—approximately 75 per cent. A total of 1,750 meters, or 40 per cent, were specifically removed for the purpose of routine testing. Approximately 8,000 have not yet received a routine test. It is evident, therefore, that an effective routine-maintenance program will require an increase of at least 25 per cent in the number of repaired meters.

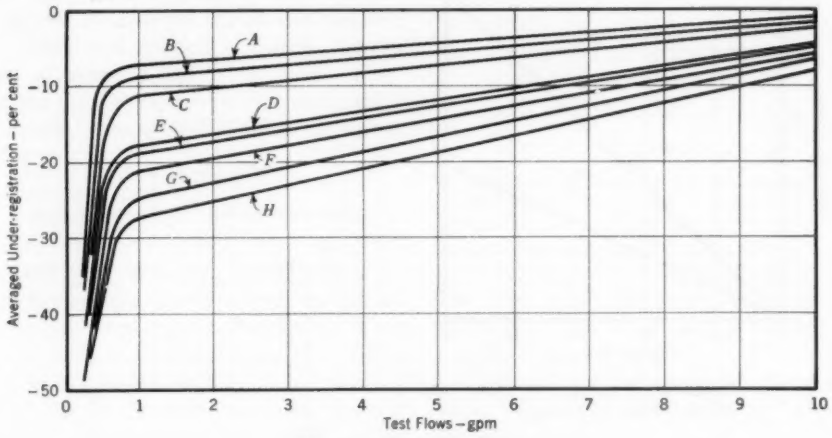

Fig. 2. Accuracy Curves

These curves show averaged under-registration for various in-service age groups. Curve A *is for the 10-year group, Curve* B *for the 15-year group, Curve* C *for the 20-year group, Curve* D *for the 25-year group, Curve* E *for the 30-year group, Curve* F *for the 35-year group, Curve* G *for the 40-year group and Curve* H *for the 45-year group.*

As of December 31, 1950, there were 48,357 meters (all sizes) in service of which approximately 92 per cent were ⅝-in. meters. The number of meters that should be repaired annually to al-

TABLE 4

Weighted Values of Under-registration and Probable Annual Revenue Loss

1	2	3
Age Group *yr*	Weighted Under-registration *per cent*	Probable Revenue Loss per Meter per yr *cents*
10	− 6.76	102.3
15	− 8.28	125.2
20	−10.32	156.1
25	−14.85	224.6
30	−16.10	243.6
35	−18.11	273.9
40	−20.82	315.0
45	−22.84	345.6

low a routine test for each meter within the present cycle of 10 yr for ⅝-in. meters (shorter period for the larger meters) is approximately 6,000.

Test Period

To establish the routine test period, the economic relationship between the probable loss of revenue and the average cost of meter maintenance must be considered. The average cost of maintenance for meters in each of the in-service age groups determined from the present analysis is given in Table 5, from which it may be noted that the costs among the various age groups do not vary greatly. The averaged costs of labor and trucking in Column 2 of Table 5 include 2.5 per cent for compensation and 5 per cent for holidays and sickness. The overhead charge in Column 4 includes administration, supervision, interest and depreciation on the building and machinery, together with building maintenance. Approximately 700 man-hours were required to remove, test, and repair the 200 routine-tested meters for the analysis.

TABLE 5

Average Costs for Maintenance of ⅝-in. Meters—1951

1	2	3	4	5
Age Group *yr*	Costs—*dollars*			
	Avgd. Labor Trucking	Materials	Overhead	Total Avgd.
10	5.05	6.44	2.05	13.54
15	5.23	7.60	2.05	14.88
20	5.14	6.80	2.05	13.99
25	5.14	7.30	2.05	14.49
30	6.03	8.15	2.05	16.23
35	4.84	8.63	2.05	15.32
40	4.83	8.79	2.05	15.67
45	4.62	9.34	2.05	16.01
AVERAGE	5.11	7.87	2.05	15.02

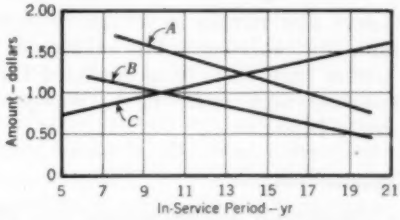

Fig. 3. Economic Limit for Routine-Test Program

Curves A *and* B *represent the average costs of maintenance in 1951 and 1941, respectively. Curve* C *represents the probable loss of revenue.*

The man-hours spent annually on meters was calculated to be 24,300, which provided a factor of 2.88 that was used to arrive at the average overhead charge per meter.

From the analysis, it has been determined that the average cost of repairing a ⅝-in. meter at this time is $15.02. An investigation in 1941 disclosed the average cost to be $9.82 for that year. The average cost of overhead per meter was found to be virtually the same as in the 1941 investigation. This ap-

parent anomaly is explained by the fact that increased work, such as for new water mains, services, renewals, and general maintenance, has required more than doubling the staff during the past ten years, whereas practically no increase has taken place in the meter section. Thus, the proportion of administration costs which is chargeable to meters has been reduced considerably.

A curve of the probable loss of revenue together with intersecting curves for the average cost of maintenance for ⅝-in. meters in 1941 and 1951 is given in Fig. 3. The economic limit for meter maintenance is the point of intersection of the curves representing loss of revenue and cost of maintenance. Meters that remain in service beyond this point represent a loss of revenue. Current high costs have extended the economic limit from 10 to approximately 14 yr.

Conclusions

The general conclusions that may be drawn from this analysis are:

1. A routine-test program is economically justified and an essential part of administering the metered system.

2. The routine-test program should be reviewed periodically to make certain that it is maintained on a sound economic basis.

It is apparent from the analysis that Winnipeg's present policy of routine-testing ⅝-in. meters once in 10 yr would be economically justified only on the basis of the 1941 maintenance costs. Therefore, until such time as there is an increase in the rate schedule or, conversely, as labor and material costs are reduced—which is most unlikely for the present time at least—it will be more economical to extend the routine test period to approximately 14 yr. This change would require the repair of approximately 4,600 meters annually based on 1950 experience. As the 1950 output was approximately 4,400 meters, an attempt to augment repair facilities in order to maintain the present ten-year cycle would not be justified at present.

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Applications of the Heat Pump

By N. C. Ebaugh

A paper presented on May 1, 1951, at the Annual Conference, Miami, by N. C. Ebaugh, Cons. Engr., Ebaugh and Goethe, Gainesville, Fla.

PRESENTED below are: a brief historical background of the heat pump, some of its present applications for air conditioning and for industrial purposes, and possible effects the heat pump may have upon water supply.

Historical Development

In 1824 a young French engineer, N. L. Sadi Carnot, presented a paper that set forth the fundamental principles upon which rests all modern power development from the application of heat (1). Twenty-eight years later, a young Englishman, William Thomson, subsequently knighted Lord Kelvin, pointed out that Carnot's principle of power generation could be applied in reverse for the heating of buildings (2).

By applying a small amount of power, a considerable amount of low-level heat could be made available at a sufficiently high level to warm buildings. Kelvin was really proposing a refrigeration machine operating in reverse. Several years later, refrigerating machines that used air as a refrigerating medium were quite extensively used. This type of refrigerating equipment became obsolete after the advent of the more efficient compression type system now used. The air-refrigeration system, however, has returned to use recently in air conditioning modern, pressurized-cabin airliners.

During the decade 1840–50, John Gorrie, a physician, developed a cold-air-refrigeration machine *. He was seeking a mechanical means of cooling his hospital rooms to expedite the treatment and recovery of patients suffering from malaria and yellow fever. He proposed to bring the beneficial summer climate of western North Carolina to Florida. Today, a century after Gorrie's efforts to air condition for health, only the more progressive hospitals have air conditioning.

The heat pump is a refrigeration machine. It has been developed only slowly into a practical machine which could be applied at reasonable cost. Approximately 200 heat pumps have been installed in Florida, and a considerable number are in operation in other states and in foreign countries. Several companies in this country are building packaged units, and others have experimental models now in operation. The probable number of heat pumps in operation in the United States, including those manufactured for refrigerator trucks, is more than 2,000 (3).

Principle of the Heat Pump

The principle of operation of the heat pump is often illustrated by the hydraulic analogy shown in Fig. 1. A small amount of high-level water can be allowed to flow through a hydraulic turbine which drives the pump and lifts a larger amount of low-level, well wa-

* U.S. Patent 8080, issued May 6, 1851, to John Gorrie, Apalachicola, Fla.

ter into an intermediate tank, to become the available water supply. If the high-tank piping, turbine, and pump were to involve no losses, a 1-gal flow from the high-level tank, which is 100 ft above the available supply, could pump 5 gal from the low-level supply, which is 20 ft below the available supply. Thus, the 1 gal used by the turbine and the 5 gal pumped from the low-level supply would both flow into the available supply, and a total of 6 gal would be provided.

If the turbine and the pump are 80 per cent efficient, 1 gal from the high-level supply will lift:

$$\frac{1 \text{ gal} \times 100 \times 0.80}{(20/0.80)} = 3.0 \text{ gal}$$

making a total available of 4 gal (1 + 3).

One heat pump which was recently designed for a small office building will serve as an illustration of the reversed refrigeration principle. A schematic diagram of this system is shown in Fig. 2.

In order to drive a conventional compressor, 10.6 kwhr or 36,200 Btu per hr of high-level electrical energy is supplied to the motor. The compressor action circulates the refrigerant * from the evaporator to the condenser. The refrigerant leaves the evaporator as low-pressure and low-temperature gas and enters the condenser as high-temperature and high-pressure gas. It returns from the condenser to the expansion valve and evaporator as liquid.

Well water at 72 F is the source of heat. It is pumped through the evaporator, in which it warms the liquid refrigerant, turning it into gas. The well water is cooled to 40 F and, in this particular heat pump, is then used for lawn irrigation. The evaporator extracts 130,300 Btu per hr from the well water. Water from the heating load at 91 F is pumped through the condenser, in which it is heated to 107 F by the hot gas from the compressor. This water is dispatched to heat the building.

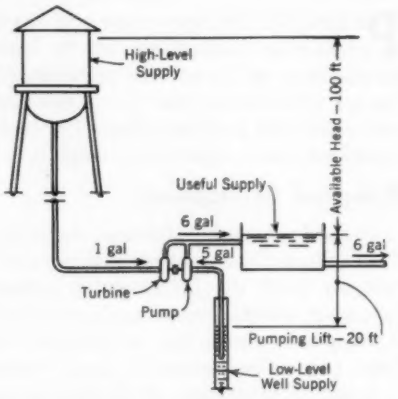

Fig. 1. Hydraulic Analogy of the Heat Pump

A small amount of high-level water allowed to flow through the turbine. Thus driven, the pump lifts a larger amount of low-level water into an intermediate tank, to become the available supply.

The heat extracted from the well water, 130,300 Btu per hr, plus the heat equivalent of the electricity used by the compressor motor, 36,200 Btu per hr is given up in the condenser, and 166,500 Btu per hr thus becomes available for heating. The coefficient of performance of a heat pump is defined as the ratio of the heat delivered to the heat equivalent of the energy supplied to drive the compressor. For the system shown in Fig. 2, the coefficient of performance is:

$$\frac{166{,}500}{36{,}200} = 4.6$$

* "Freon 12," a product of Kinetic Chemicals, Inc., Wilmington, Del.

This system was specifically designed for a particular load and has a larger coefficient of performance than does the average heat pump. The usual packaged type of heat pump, which uses water as the source of heat, offers performance coefficients of approximately 3.0–3.5.

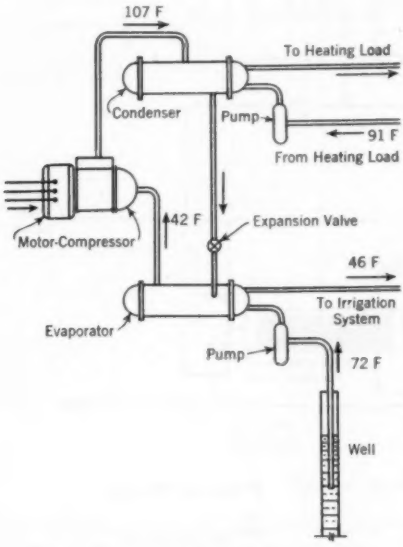

Fig. 2. A Typical Heat Pump Application

Well water at 72 F—the source of the heat—is pumped through the evaporator, in which it warms the liquid refrigerant, turning it into gas. The process cools the water to 46 F, at which level it is used for irrigation. The hot gas is used to reheat 91 F water from the heating load to 107 F, at which level it is returned to the heating load.

It is noteworthy that the heat pump makes available several times as much heat energy as would be obtained from the electricity alone. The ability to multiply high-cost, high-level energy makes the heat pump practical for comfort heating and for industrial applications.

Heat Sources

Low-level heat energy can be obtained in several ways. Water may be furnished from a municipal supply or from lakes or streams rather than from a well as illustrated in Fig. 2. Ground water or other naturally available water is the most practical source of low-level energy, but some units operate by utilizing heat directly from the atmosphere in an air-to-air unit. Heat may also be obtained from coils buried in the earth or from coils in a static well.

When air is used as a heat source, the capacity of the heating system is reduced when it is most needed, in cold weather. Furthermore, when the evaporator, which absorbs the heat from the atmosphere, reaches surface temperatures of 32 F or lower, defrosting is necessary. The air-to-air heat pump can be expected to have a 2–3 performance coefficient (4).

The direct extraction of heat from the earth with a buried ground coil depends upon the conductivity of the soil in the vicinity of the heat pump. For the sandy types of soil found in peninsular Florida, this system requires approximately 80 ft of ½-in. tubing for each 1,000 Btu per hr produced by the heat pump (5). In Seattle, Wash., with a soil of much higher thermal conductivity, approximately half this amount of tubing is required (6). In Florida, therefore, the average six-room house would require almost a mile of tubing to gather sufficient heat for the pump. Even if the cost of the tubing were reasonable, the usual lot would be too small to accommodate that much pipe.

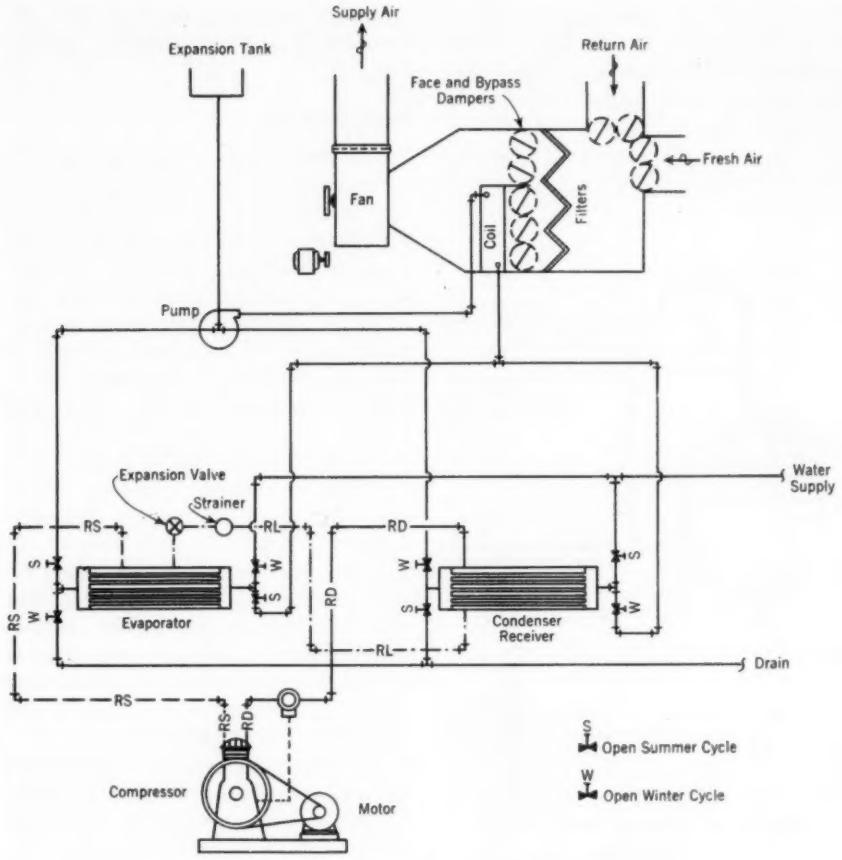

Fig. 3. Year-Round Air Conditioner

This air conditioner provides year-round service with a direct refrigeration system. The letters, "RL," "RD," and "RS," represent refrigerant liquid, refrigerant discharged, and refrigerant suction, respectively.

The high initial cost of the heat pump, compared with that of conventional heating systems, precludes its use for comfort heating only, but, if air conditioning is desired, the refrigeration unit may be used as a heat pump. A system is thus available without fuel, ashes, smoke, or fumes, and no chimney or fuel storage is required.

Water-to-Water System

Figure 3 shows one method of securing year-round air conditioning with an indirect-refrigeration system. In this system, water from the water supply may be circulated through either the evaporator or the condenser. A pump circulates water through another closed system, through either the evap-

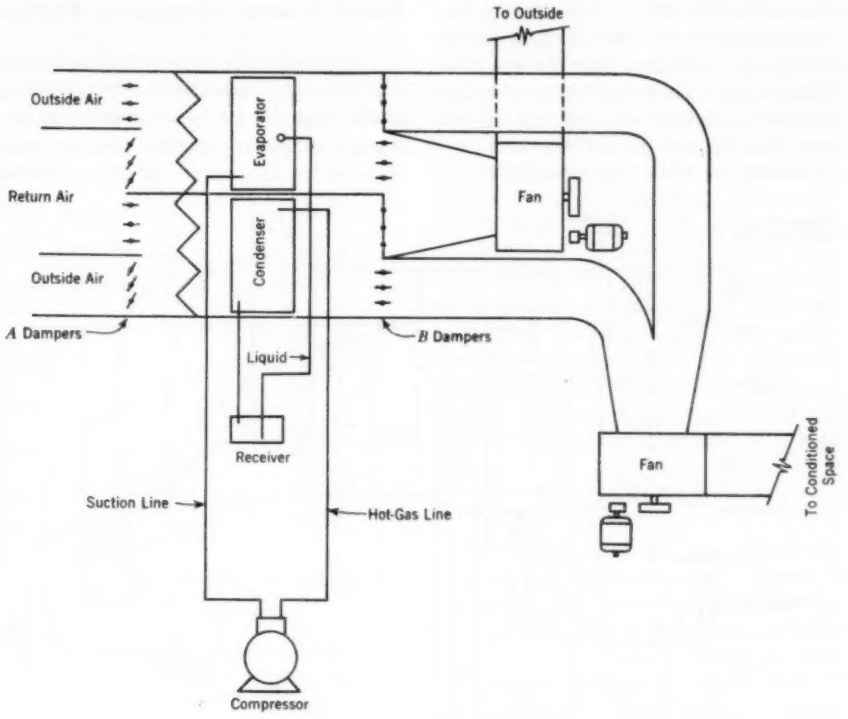

Fig. 4. Air-to-Air System

This system heats and cools with direct refrigeration. Dampers in Group A rotate 60 deg upon change of cycle, and those in Group B rotate 90 deg upon cycle change. All damper positions are shown for winter-cycle operation. Refrigerant flows are identical for both cycles.

orator or the condenser, to a suitable coil in the air conditioner as shown on the top of the diagram. When heat is desired, this water is pumped through the air-conditioner coil and then through the condenser, in which it is warmed and returned to the coil. Water from the supply is sent through the evaporator, in which it gives up heat, and is then discarded or used for some other purpose.

When cooling is desired, the water valves are reversed so that the water in the closed system flows through the coil in the air conditioner and through the evaporator, in which it is cooled before returning to the coil. Supply water is sent through the condenser and then through the drain as is usual for every refrigeration system. Only water valves are opened and closed. The refrigeration system operates in the same manner during summer and winter.

Air-to-Air System

An air-to-air system employing direct-expansion refrigeration equipment

is shown in Fig. 4. In this system, two fans are required. One of them pumps outside air, and the other pumps conditioned air. Each fan has two sets of dampers arranged so that one set allows conditioned air to flow through the condenser when heat is desired, and the other allows outside air to flow through the condenser when cooling is desired. The dampers are interlocked so that outside air is pumped through the evaporator on the heating cycle and through the condenser on the cooling cycle.

Use of Internal-Combustion Engine

To increase the economy greatly and to overcome somewhat the frosting problem in the air-to-air system, an internal-combustion engine may be substituted for the motor drive, as shown in Fig. 5. The system illustrated has the same arrangement as that shown in Fig. 4, with two fans and two sets of dampers for each fan. In addition, heat from the jacket water of the diesel engine may be added to the heat obtained from the condenser on the heat-

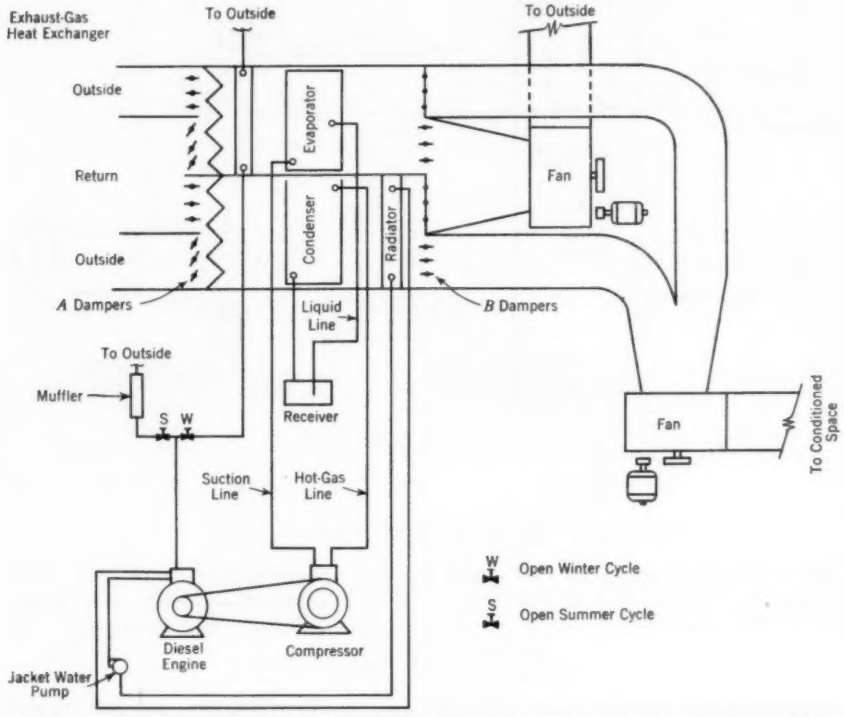

Fig. 5. Heating and Cooling With Diesel-Engine-Driven Compressor and Utilization of Waste Heat

Dampers in Group A *rotate 60 deg upon change of cycle. Those in Group* B *rotate 90 deg upon cycle change. All dampers shown in winter-cycle position. Refrigerant flows are identical for both cycles.*

ing cycle. Also, heat from the exhaust of the engine may be applied to the air ahead of the evaporator to improve evaporator performance and to decrease the difficulties of frosting when the evaporator-surface temperature approaches 32 F.

Fuel Costs

Figure 6 shows comparative fuel costs for No. 3 fuel oil, 1,000 Btu per

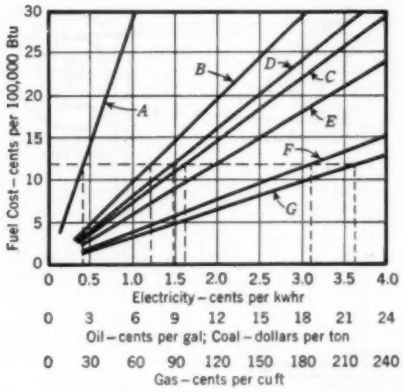

Fig. 6. Comparative Fuel Costs

Curve A *shows cost for direct electric-resistance heaters; Curves* B *and* C, *for electric-driven heat pumps with performance coefficients of 3 and 4, respectively; Curve* D, *for 1,000 Btu per cu ft natural gas; Curve* E, *for No. 3 fuel oil; Curve* F, *for diesel-engine-driven heat pump; and Curve* G, *for 13,500 Btu per lb coal. Oil was assumed to burn with 75 per cent efficiency, gas with 80 per cent, and coal with 70 per cent.*

cu ft natural gas, 13,500 Btu per lb coal, direct electric-resistance heaters, electric-driven heat pumps with performance coefficients of 3 and 4, and the diesel-engine-driven heat pump. Oil was assumed to burn with 75 per cent efficiency, gas with 80 per cent, and coal with 70 per cent.

A horizontal line drawn through the curves will indicate the various prices of fuel which will result in the same fuel cost per therm (100,000 Btu). The broken line shows that, for a cost of 12¢ per 100,000 Btu, the following fuel prices will have to be obtained: direct electric resistance, 0.4¢ per kwhr; heat pump with performance coefficient of 3, 1.2¢ per kwhr; gas, 90.0¢ per 1,000 cu ft; heat pump with performance coefficient of 4, 1.6¢ per kwhr; oil, 12.0¢ per gal; heat pump with engine drive, 19.0¢ per gal; coal, $22 per ton. This tabulation indicates that, in most localities, the heat-pump fuel price is lower than that of gas or oil.

Compression Still

The principle of the heat pump has been applied in many ways. Figure 7 illustrates the operating cycle of the compression still in producing potable water from sea water. Many of these stills were used during World War II on submarines, naval surface vessels, and barren islands.

Sea water is pumped through the heat exchanger into the evaporator. After the sea water is evaporated, the steam that is formed at 212 F is compressed to 3 psi and 222 F and piped to the jacket space surrounding the evaporator tubes. Here it gives up its heat to the boiling sea water and is condensed. The distilled water thus formed flows out to storage through the heat exchanger. The salts in the sea water are left behind in the evaporator. A continuous blowoff of brine is required to limit the dissolved solids to a reasonable amount.

These stills are available with both electric-motor and diesel-engine drives. The electric unit produces approximately 1,000 gal of distilled water per

100 kwhr input, and the diesel unit requires approximately 7.5 gal of oil per 1,000 gal of water. This evaporator requires no condenser cooling water as does the conventional multiple-effect evaporator, and the overall economy is almost equal to that of a 15-effect unit *.

8 was developed by Majonnier Bros. Co. of Chicago, Ill.

The cycle is analogous to that of the compression still except that, instead of compressing the water vapor directly, as in the still, a heat-transfer medium (ammonia) is used. Citrus juice is introduced at the inlet shown

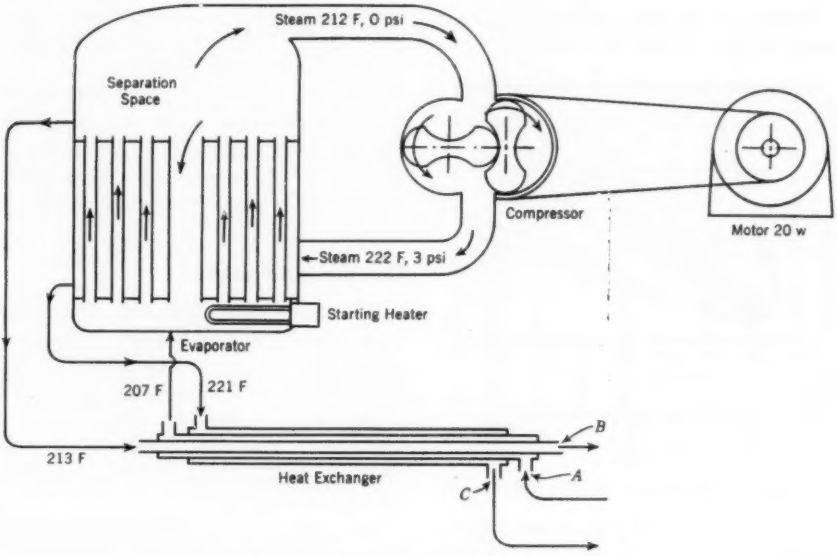

Fig. 7. Distilled Water Production

This arrangement of equipment shows how heat pump may be used in producing distilled water. Pipe A *takes in 60 F sea water at a rate of 1.25 lb per hr. Pipe* B *expels 80 F brine at rate of 0.25 lb per hr. Pipe* C *expels 70 F fresh water at rate of 1.0 lb per hr.*

Concentration of Citrus Juice

A paper written in Florida is hardly complete without mentioning oranges. The heat-pump principle is being used to manufacture concentrated citrus juice †. The arrangement of equipment for this purpose as shown in Fig.

in the lower right of the diagram and enters the juice heater, which is also the ammonia condenser. The partially vaporized juice at about 60 F flows from the heater to the vapor separator. The concentrated juice leaves the bottom of the separator and the vapors (principally low-pressure steam) leave the top and are condensed in the juice-vapor condenser. This condenser is cooled by boiling ammonia.

* Private communication from Arthur D. Little, Inc., Cambridge, Mass.

† Private communication from Frick Co., Waynesboro, Pa.

The directional arrows on the diagram show that the ammonia travels in a closed circuit from the evaporator to the compressor, to the condenser, to the ammonia tank, and back to the evaporator. Through application of the heat-pump principle, the juice is heated, the vapor is condensed, and the electrical power required to drive the ammonia compressor is the source of high-level energy.

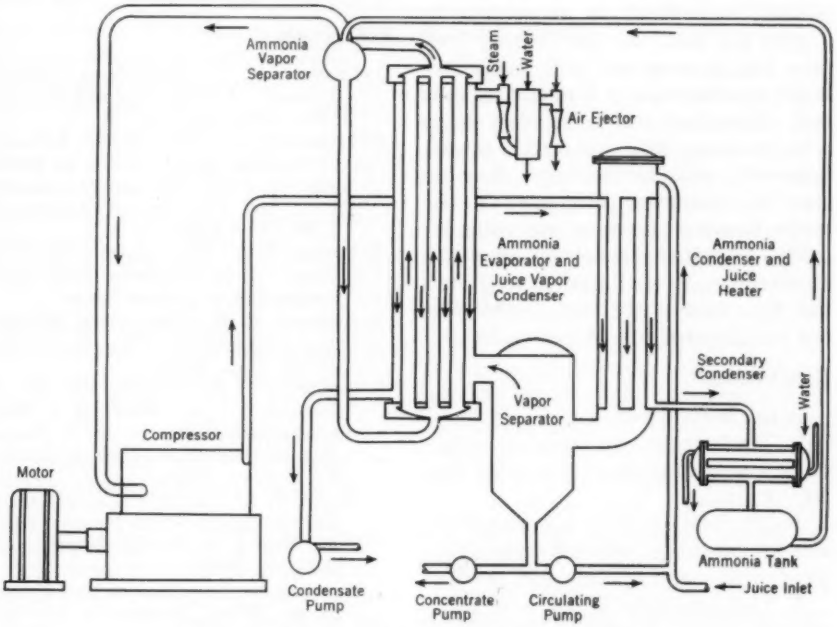

Fig. 8. Industrial Application of Heat Pump

The equipment is arranged for the manufacture of concentrated citrus juice.

Water Requirements

It has been shown that a source of water is usually the best heat supply for the heat pump as presently developed. The amount of water used for heating in winter will generally approximate the amount used for cooling in summer. The water problems created by the heat pump in summer, therefore, are the same as those created by conventional air-conditioning systems.

Air conditioning systems are creating serious water supply and disposal problems in metropolitan areas, and regulatory measures have already been taken in many cities. Several valuable articles have already been published on this subject (7–9). The Association's Committee on Water Use in Air Conditioning and Refrigeration has also published its report together with a "Model Ordinance Regulating Installation and Operation of Air-Conditioning and Refrigeration Equipment (10)."

Recirculation of the cooling water in air-conditioning systems as a con-

servation measure is economically desirable and generally practiced. Recirculation of the source of water for heating with a heat pump, however, is not possible during freezing weather. A source-water temperature of 45 F is approximately the lowest practical limit and at this temperature approximately 3 gpm per ton of refrigeration (also approximately this amount per compressor horsepower) is required. If water at 70 F is available, the required amount is reduced to approximately 1 gpm per ton. As the heating load may not correspond with maximum water consumption in a municipal system, municipal water supplies may, without conservation measures, be satisfactorily used for heating. A separate determination will have to be made, however, for each particular locality. Another expression of water requirements is that from 1 to 3 gpm will be required for each 10,000 Btu per hr delivered by the heat pump.

Conclusions

It has been shown that:

1. The heat pump is based on refrigeration principles developed more than 100 yr ago.

2. The heat pump is a practical device for providing, with the same equipment, year-round cooling and heating.

3. The principle of the heat pump may be applied industrially in producing fresh water from sea water or such processes as the production of juice concentrates.

4. A source of water is the most practical source of low-level heat for the heat pump.

5. From 1 to 3 gpm of water is required, depending upon the water temperature available, for each horsepower of input power or for each 10,000 Btu per hr of heat delivered.

6. The heat pump creates water problems analogous to those of air-conditioning systems and should receive the attention of the water works industry.

7. The principle of the heat pump may be used to alleviate water supply problems in some industrial processes.

Acknowledgment

Figures 3, 4, and 5 were prepared by S. P. Goethe (11).

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Discussion

By Claud R. Erickson

Mech. Engr., Board of Water and Electric Light Comrs., Lansing, Mich.

The author's presentation represents a significant contribution to literature on the heat pump. In addition to its other merits, it offers actual operating data, which are all too scarce. To measure the effectiveness of the heat pump, the term "coefficient of performance" is used. This term is taken from refrigeration practice and, as applied to heat engines, is comparable with the term "efficiency." A more accurate and descriptive term to rate the efficiency of a heat pump would be "performance factor." This term could be qualified to measure the performance when the unit was being used for heating, and also when used for cooling.

The term "heating with reversed refrigeration" is misleading. Whether the refrigerant is used for heating or for cooling, it follows the same four steps in the cycle:

1. The vapor is compressed from a low temperature and low pressure to a higher temperature and higher pressure.

2. The refrigerant is introduced into a condenser, in which the heat is extracted and the vapor condensed.

3. The high-pressure liquid is expanded through an expansion valve to almost the initial low pressure.

4. The refrigerant passes through the evaporator, in which another quantity of heat is obtained.

If these four principal elements of the heat pump could be connected by rubber tubing and the outside air used as the heat source, the operation could meet the following simple description:

1. When heat is required in the house, the evaporator is placed outside a window while the condenser remains inside.

2. When the house is to be cooled during the summer, the evaporator is brought inside, and the condenser is put outside.

Heating Water

Another field for the application of the heat pump is the provision of domestic hot water. To determine the economics of design and operation, several units were built and are now being used in actual installations. These units will have a greater initial cost but should require lower operating cost.

At present the heat pump is definitely a luxury. Time alone will determine its economic justification. By its nature, heat-pump equipment requires a higher initial investment than conventional heating units. For economic survival, the heat pump will have to provide compensating advantages, such as lower operating costs and the other advantages stated by the author.

As the demand for the heat pump increases, technical improvements may be expected, and the performance factor may be increased to as much as 5.0. Use of the heat pump may be extended by combining several household functions, such as food refrigeration, deep freezing, and hot and iced water supply, with the heating and cooling of the home.

Establishment of Rate Differentials Inside and Outside City Limits

By F. Burton Smith

A paper presented on Oct. 30, 1951, at the Florida Section Meeting, Daytona Beach, Fla., by F. Burton Smith, Vice-Pres., Florida Utilities Corp., Orlando, Fla.

QUESTIONNAIRES answered by water superintendents throughout Florida indicate a general agreement that water users outside city limits should pay more for water, in one way or another, than is paid by those inside. Methods of setting up the different scales, however, vary widely.

Of the cities that replied, 30 per cent either have no customers beyond city limits, or have less than 2 per cent of their total customers there. Of the remaining cities, 82 per cent differentiate between inside and outside customers, half of them, or 41 per cent, having rate differentials which impose surcharges of from 5 to 66⅔ per cent on outside customers. Stricter extension policies outside the city limits are adopted by 62 per cent. The usual difference is that out-of-city customers are required to pay for pipe laid by the utility, whereas the utility furnishes such pipe to city customers.

Hydrant rentals are charged in only 46 per cent of the cities reporting. Revenues from this source are 2–9 per cent of the total water revenues, and the average is 4.6 per cent. In only three cities are fire hydrants installed outside the city at utility expenses. In 92 per cent of the cities, fire departments answer calls outside the city limits, but in only 25 per cent of them are charges made for this service.

Tapping fees are collected by 90 per cent of the cities. Charges on ¾-in. meters vary from $1.50 to $40.00; on 1-in. meters, from $10.00 to $85.00.

Operating expenses vary from 24 per cent to 101 per cent of revenues, the average being 54 per cent.

Surplus water revenue is diverted to general municipal funds in 26 per cent of the cities reporting.

Water revenue bonds are outstanding in 61 per cent of the cities, 26 per cent have pledged surplus water revenues to finance sewer improvements, and 49 per cent collect utilities service charges on water bills.

With such widely varying operating conditions, no single rate differential will apply in all cities. Instead, it is hoped a standard procedure can be developed which, if followed, will enable each city to establish justifiable differentials in charges that will be fair to both inside and outside customers.

Fundamental Concepts

Fundamental concepts suggested for basing rate differentials are:

1. Because most municipally owned water systems were financed with gen-

eral obligation bonds and paid for by property owners within the city limits through ad valorem taxes, the taxpayers occupy the same position as stockholders in a private corporation. They are therefore entitled to earn a fair return on their investment. To accomplish this end, rates to out-of-city users should be comparable to those that would be charged by a private company operating under similar conditions.

2. A water system serves two functions: to produce, process and distribute water to the users; and to furnish, additionally, water for fire protection. The total annual revenues of the water system should be contributed by users, both inside and outside the city, and by property owners in approximate proportion to the cost of the facilities required for each group.

If these two concepts are accepted, the problem of determining equitable rate differentials between city and non-city users is reduced to three steps: [1] fixing the revenues which the water system, if privately owned, would reasonably earn; [2] making applicable adjustments for out-of-city users, calculating the increased cost of serving them and the credit which should be allowed for any services not received by them; and [3] comparing the adjusted revenues on which rates to out-of-city users should equitably be based with the revenues currently earned by the water system. The resulting rate differential would be quite justifiable.

Effects of Florida Laws

Any study of water rates in Florida must take into account the effect which Florida laws have on both the method of collecting charges and the amount of total revenues collected. In many northern cities, a substantial part of water revenues is collected through ad valorem taxes. That a large portion of the cost and maintenance of the plant and transmission mains is properly chargeable to fire protection is a recognized principle. It follows, therefore, that such costs should be paid by property, through ad valorem taxes, and not by water users. In Florida, however, the Homestead Amendment exempts from taxation property valued at less than $5,000. Only part of the cost of fire protection, therefore, can be collected through ad valorem taxes in the form of hydrant rentals. The balance must be collected from homestead property indirectly through increased water rates.

In some states, general obligation and special assessment bonds are often used to finance water improvements. Florida laws, however, restrict the issuance of these securities, and, therefore, Florida cities must rely on revenue financing. Successful revenue financing depends on operation of the water systems at profits adequate to enable advantageous sale of the bonds.

Many cities raise water rates to build a surplus that is diverted to general municipal funds. It is logically reasoned that homestead property can thus be taxed its fair share of city expenses which would otherwise not be so paid because of the Homestead Amendment.

Obviously, that portion of water revenue diverted to a city's general fund should not be passed on to out-of-city customers except to the extent that they benefit from the facilities or services provided by the city.

It is also recognized that political and other considerations often play a dominating role in establishing rate differentials outside city limits. Some

cities actually charge high water rates and establish harsh extension policies to penalize out-of-city users for not residing in the city. Orlando, on the other hand, has the most liberal main extension policy in Florida, extending mains beyond its limits without cost, if anticipated revenues justify the expenditure. Orlando also has one of the lowest water rates in the state. Water revenues from these out-of-city customers, therefore, are obviously insufficient to justify such a liberal extension policy. The answer is that those who benefit from this liberal extension policy and the low water rates must also buy electricity from Orlando's municipally owned plant. In 1950 the profits derived from Orlando's electric system were almost $2,000,000, of which a substantial part was placed in the city's general fund.

Total Revenue Determination

In establishing a rate differential, the first determination is that of the total revenue which the water system could earn if it were operated as a private company. The calculation of this theoretical revenue includes the following steps:

1. Present operating expenses should be computed and carefully analyzed to insure the exclusion of capital expenditures from among them. Most cities penalize themselves unnecessarily by improper accounting procedures. Two factors that the accountant should check carefully are:

a. Capital improvements must be correctly recorded and not included among operating expenses. Labor and materials, auto and equipment expenses, and a fair portion of supervision and administrative cost should be included. Time sheets and complete job records are suggested for each employee, so that accurate capital expenditures can be properly recorded.

b. Operating income should include —even if only as a bookkeeping entry —a charge against the general city fund for public fire protection service, or hydrant rental. This entry is important if revenue financing is contemplated for the future. The number of bonds that can be issued is in direct proportion to the surplus shown in the operating statement. Good statements also result in lower interest costs on bonds that are issued.

2. Approximately 5–10 per cent of revenues should be placed in a reserve for renewals and replacements. This practice is mandatory if revenue bonds are issued to replace depreciation costs charged by a private company.

TABLE 1

Theoretical Revenues

Factor	Amount
Operating expenses (54 per cent of revenue)	$108,000
Renewal and replacement reserve (8 per cent avg.)	16,000
Interest at 4 per cent on assumed $250,000 revenue bonds	10,000
Fair return (6 per cent on $750,000)	45,000
Ad valorem taxes (7 per cent assumed)	14,000
Federal income tax (52 per cent of $45,000)	23,400
TOTAL	$216,400

3. Interest on any outstanding water revenue bonds must be noted.

4. A fair return should be estimated on the taxpayers' investment or equity. Courts and regulating authorities have approved water rates which include a 6 per cent return on invested capital. Equity on which the taxpayer is entitled to return is the total cost of the water system including property additions, which would have to be estimated if current capital investments were improperly included in operating expenses. If this figure is not readily

available or is obviously too low, an appraisal of the current value of the plant could be used instead of cost. From this amount should be deducted any revenue bonds issued.

5. Taxes must be recorded. A private water company would pay ad valorem taxes to the city and county and income taxes to the federal government. These taxes would ultimately be paid by the water users. An analysis of private water company operations in Florida reveals that an average of 7 per cent of revenue is paid to cities and counties as ad valorem or occupational license taxes. Income taxes would be figured at prevailing corporation rates and applied to the fair return.

TABLE 2

*Fire Insurance Rates for Similar Frame Dwellings in or Near Class-V–VII Cities**

Location	Rate ¢ per $100
Outside city (beyond 5 miles)	65
Outside city (within 5 miles)	49
Outside city (within 1,000 ft of hydrant)	35
Inside city (within 1,000 ft of hydrant)	28

* Classified according to National Board of Fire Underwriters standard schedule.

The total of the foregoing amounts would be the revenues upon which a private company would be allowed by regulatory authorities to compute its return.

For illustration, a water system may be assumed to have a rate base, or value, of $1,000,000, of which $750,000 was paid by taxpayers and $250,000 was financed by issuing revenue bonds. Present total operating revenues are $200,000, of which $10,000 is hydrant rental paid by the municipality. Proportions shown in Table 1 are averages obtained from analyses of municipally and privately owned water systems in Florida.

Analysis of Revenue Factors

After total revenues are determined the various factors which comprise them should be analyzed and equitable adjustments for out-of-city users should be calculated.

The costs of producing, treating, and purifying water are obviously the same regardless of the point of sale. The cost of delivering water to customers outside the city limits, however, is normally greater than the average cost of delivering it inside the city. This increase is reflected in pumping costs and in maintenance of transmission mains and pumping equipment. Not only must the costs of delivering water be analyzed, but also the costs of reading meters, servicing customers, and any other expenses that vary with distance. The additional cost of serving customers outside the city can thus be estimated.

It is assumed, for example, that half the total pumping cost is for transmission of water from the plant to the customer, and friction loss is sufficient to require 40 per cent more electricity to pump water outside the city than to the average city customer. The logical differential, therefore, is 20 per cent of the total pumping cost. If pumping costs are 10 per cent of the total revenue, a rate differential of 20 per cent of 10, or 2 per cent, is justified by this item alone. If this procedure is applied to customer accounting and other operating costs, a total proportional or dollar differential is justified merely by operating costs.

Extension policies require adjustments in the differentials that would otherwise be charged out-of-city customers. If customers outside the city limits are required to pay for all or part of the main extensions needed to serve them, they too have an equity proportional to their investment in the plant, and the return which taxpayers receive must be reduced accordingly.

The net equity in the water system is represented by hypothetical capital assets of: plant, $150,000; transmission mains, $300,000; distribution mains, $300,000—yielding a total of $750,000. The city's extension policy is assumed to require an out-of-city customer to bear the entire cost of water mains laid to serve him. The net equity on which the taxpayers should earn a return is therefore reduced by the value of the city's distribution mains, or $300,000. The fair return, therefore, should be reduced by 6 per cent of $300,000, or $18,000. If the city pays half the cost, this adjustment should be cut in half, and, if the cost of the main is ultimately refunded, no adjustment is necessary.

Another basis for adjustment is the amount of fire protection provided by the city to out-of-city users. Property located within 5 miles of a fire station is benefited by reduced fire insurance rates. Within 1,000 ft of a hydrant, the benefit is still greater, as indicated by the comparative fire insurance rates in Table 2. The mere existence of a fire station, which is operated with taxpayers' money, is responsible for a saving on insurance of 16¢ per $100 insured if property located is within 5 miles of the station. An additional 14¢ is saved if a hydrant is within 1,000 ft of the property. If hydrants are placed so that property owners can benefit from lower insurance rates, a differential in water rates is equitable to compensate the city for providing this service.

An analysis of several city audits reveals that fire department expenses

TABLE 3

Theoretical Revenue Adjustments

Reason for Adjustment	Increase or (Decrease)
Increased Operating Costs	
Pumping costs (2 per cent of revenues)	$ 4,000
Other costs (3 per cent of revenues)	6,000
TOTAL OPERATIONAL DIFFERENTIAL	10,000
Extension Policy (value of mains, $300,000)	
Full cost paid by user (6 per cent of $300,000)	($18,000)
Half cost paid by city	(9,000)
Cost refunded	0
Fire Protection (plant value $150,000; transmission mains $300,000; 25 per cent of both, $112,500 allocated for fire protection)	
No hydrant rental paid by city; no fire service outside city limits (6 per cent of $12,500)	($ 6,750)
Hydrant rental of $10,000 paid by city; no fire service outside city limits ($10,000 less $6,750 credit)	3,250
Hydrant rental of $10,000 paid by city; fire service outside city limits	10,000

vary from $2.00 to $8.50 a year for a house with an assessed value of $5,000. The cost of answering a fire call outside the city is naturally higher than the cost of an inside call. The addition of a 25–50¢ monthly charge to the minimum water bills of out-of-city customers would probably compensate the city for this cost and would be fair to the water user. If no fire service is provided beyond the city limits, the rate differential should be adjusted. The amount of such adjustments should be based on a reduction of taxpayer equity equal to the value of the plant assigned to fire protection. This amount would include the cost of increased pumping and storage facilities as well as larger transmission mains needed solely for fire protection. Table 3 gives theoretical revenue adjustments for a system operated as a private company.

Actual and Theoretical Revenues

The final step is calculating equitable rate differentials is to compare actual operating revenues of the system with the theoretical revenues of the same system if operated as a private company. This difference will provide a justifiable rate differential. To illustrate these final calculations, as given in Table 4, it may be assumed that [1] the operating conditions and valuations prevail as previously shown; [2] by furnishing pipe, the out-of-city pays approximately half the cost of mains constructed to serve him and no refund is made by the city; [3] the city pays $10,000 hydrant rentals and its fire department serves outside the city limits. Not included is the suggested 25–50¢ monthly increase to compensate the city for complete fire protection service outside the municipal boundaries.

TABLE 4

Comparison of Revenues

	Revenues		
	Before Adjustment	Adjustment	Final
Operating expenses (54 per cent)	$108,000	$10,000	$118,000
Renewal and replacement reserve (8 per cent)	16,000	—	16,000
Interest on 4 per cent revenue bonds	10,000	—	10,000
Fair return	45,000		
For extension policy		−9,000	
For fire protection		10,000	46,000
Taxes			
Ad valorem (7 per cent)	14,000	—	14,000
Federal income	23,400	—	23,400
TOTAL	$216,400	$11,000	$227,400
Existing revenues			200,000
Indicated differential (increase)			$ 27,400
Proportional differential—*per cent*			13.7

Summary

That a differential in water rates should be made between rates paid by users inside and outside the city limits is generally agreed. The main basis for providing a differential is the fact that taxpayers usually finance their water system through ad valorem taxes and, consequently, are entitled to a return on their investment. This return should approximate the profit that would be earned by a private company.

The additional cost of serving out-of-city customers should be estimated and billed to them. Conversely, credit should be given if property owners beyond the city limits are required to install their own mains or are not given fire protection service. If a logical approach is taken, a rate differential, fair to all water users and property owners, can be developed. Municipalities should explore the possibility of rendering greater service to out-of-city areas. If proper rate differentials are established, the resulting revenues can be profitable to the taxpayers.

Fluoridation Resolution by the American Medical Association

The following resolution by the Committee on Hygiene and Public Health of the American Medical Assn. was adopted by the House of Delegates at the Clinical Session in Los Angeles, Calif., December 4–7, 1951 (Jour. Am. Med. Assn., Vol. 147, No. 17, p. 1698, Dec. 22, 1951):

WHEREAS, Carefully controlled studies have demonstrated that fluoridation of water supply has been definitely beneficial in the reduction of dental caries in the younger age group; and

WHEREAS, The Council on Pharmacy and Chemistry has reported that fluoride is nontoxic in community water supplies up to one part per million; and

WHEREAS, The addition of fluoride to community water supplies seems to have merit; therefore be it

RESOLVED, That the House of Delegates of the American Medical Association endorse the principle of fluoridation of community water supplies.

California Water Permit Law

By H. J. Ongerth

A paper presented on Oct. 26, 1950, at the California Section Meeting, San Diego, Calif., by H. J. Ongerth, Sr. San. Engr., Bureau of San. Eng., State Dept. of Public Health, Berkeley, Calif.

IT seems appropriate at this time to discuss a 1913 California law because in 1947, and again in 1949, the legislature made important amendments to the act. In October 1948, moreover, the California Section of AWWA contributed to the act by promulgating "Standards of Minimum Requirements for Safe Practice in the Production and Delivery of Water for Domestic Use," (1) and these standards have, by reference, been incorporated into the Water Permit Act (Appendix).

The heart of this Act is contained in Section 4031, which sets forth the provision that:

> It is unlawful for any person to furnish or supply to a user water used or intended to be used for human consumption or for domestic purposes which is impure, unwholesome, unpotable, polluted, or dangerous to health.

and Section 4011, which reads:

> No person shall furnish or supply water to a user for domestic purposes from any source of water supply unless he first files a petition for permission so to do from the State Board of Public Health and receives a permit as provided in this chapter.

The act contains a further provision that states:

> With the petition shall be filed a complete set of plans and specifications, together with a statement containing a general description and history of the existing or proposed plant, works, or system or proposed changes therein, and showing the geographical location thereof with relation to the source of the water supply and all the sanitary and health conditions surrounding and affecting such supply and the plant, works, or system.

In Section 4014 the act requires that:

> . . . the State Board of Public Health shall make a thorough investigation of the proposed plant, works, system or water supply, and all other circumstances and conditions which it deems material.

Following this investigation, according to Section 4021:

> If the Board determines that the water being furnished or supplied is such that under all the circumstances and conditions it is pure, wholesome, and potable, and does not endanger the lives or health of human beings, it shall grant a permit authorizing the petitioner to furnish, or continue to furnish or supply the water.

In essence, then, the act requires that every supplier of water have a permit from the State Board of Public Health to furnish domestic water, that application be filed with the board for such permit, that the State Dept. of Public

Health * make thorough investigation of the proposal and, finally, if it is determined that the water being furnished is pure, wholesome and potable, that the permit be granted to the applier.

Codification of Law

In 1939 when various health and safety laws were codified by the California State Legislature, the water permit law was not included in the Health and Safety Code—probably because the legislature felt that water works operation is a proprietary rather than a governmental function. In 1947, at the request of the State Dept. of Public Health, this law was included in the Health and Safety Code for various reasons, among them the desire to make it more readily available to water works men and other interested people. As the result of this proposed codification, members of the water works profession became aware of some of the long-standing provisions of the law. They were startled to learn that no modification, addition or change could be made to a source of supply, method of treatment or any part of a distribution system unless a petition were filed with the State Board of Public Health and a permit granted. In accordance with a strict or technical interpretation of the law, no water works operator could extend a water main even a few feet down the street without first filing such a petition supported by plans and specifications. Naturally, the granting of a permit would be necessary before work could be done. This interpretation, it is felt, is unreasonable and such an act by a governmental bureau would not be supported by the courts. Actually, to the author's knowledge, this provision was never so administered.

Modification of Act

In 1947 due to the efforts of water works people, including members of the American Water Works Assn. California Section, the act was modified to read:

> No person shall modify, add to, or change his source of supply or method of treatment of water or change his distribution system for water for domestic purposes as authorized by valid existing permit issued to him by the State Board of Public Health, unless he first files a petition so to do with said board and receives an amended permit, or unless such modifications comply in all particulars with such of the mandatory requirements of the water works standards as pertain to the quality of water supplied to consumers.

These are the standards that were approved by the California Section of the American Water Works Assn. on October 29, 1948, and entitled, "Standards of Minimum Requirements for Safe Practice in the Production and Delivery of Water for Domestic Use (1)."

Only the intent and purpose of these standards need be discussed. Paragraph 2.1 states: "It is the intent of these standards to safeguard domestic water consumers from injury resulting from sanitary hazards . . . which may arise from inadequacies in design, construction, maintenance, and operation of water utility systems." Paragraph 2.2 states: "It is the purpose of these minimum requirements to outline standards . . . which will provide protection of the public health." Other sections of this standard cover the water system, quality of water, design and

* The State Dept. of Public Health administers laws and regulations of the State Board of Public Health and performs executive and administrative functions.

construction, and operation and maintenance. The Water Permit Act of the Health and Safety Code, and these minimum standards of the AWWA California Section have been reprinted by the State Dept. of Public Health, and are available for distribution from the office of the Bureau of Sanitary Engineering upon request (1).

The effect of a law upon those regulated by it depends in large measure upon how the law is administered. The possession of a water permit is a legal requirement established by the legislature. The State Department of Public Health believes that it should attempt to carry out the intent of the legislature in a reasonable manner. The word "reasonable" must be stressed for all the department's actions are tested by the criteria of whether or not they are reasonable. Its primary obligation is to make certain that water being furnished to the pubilc is, under all circumstances and conditions, pure, wholesome, potable, and not dangerous to the lives or health of human beings. In the effort to reduce to a minimum the risk in a given situation and to provide maximum protection of public health, some actions of the administrative agency may be unreasonable or be considered an unreasonable assumption of authority. To avoid such incidents requires the highest sort of technical competence and administrative and technical judgment.

Other Literature

As a guide for judging water works, the standards of the California Section and various publications of the U.S. Public Health Service are available. Two such publications merit special attention: the "Manual of Recommended Water Sanitation Practice" (2) developed in cooperation with water works men and published as a supplement to the 1946 Drinking Water Standards and "Sanitation Manual for Ground Water Supplies" (3), developed by a committee of the Conference of State Sanitary Engineers. A most important guide is the judgment of engineers of the Bureau of Sanitary Engineering, based upon knowledge of and experience with public health and water works practice.

The criteria established by the California Legislature for judging a water system are its continuous purity, wholesomeness and potability. These terms are all abstractions which, fortunately, can be reduced to more concrete, measurable expressions. Purity, of course, is measured by various bacteriological tests, particularly the well known test for coliform organisms. The standard for judging the purity of water in accordance with this test is the 1946 "Public Health Service Drinking Water Standards" (4). Standards for judging wholesomeness and potability are not as well defined. These terms, in fact, are not absolute standards but vary from place to place. City dwellers of Oakland, who for many years have received a filtered water supply, would certainly consider unwholesome and unpotable some of the ditch water supplies that are available in some mountain communities and are completely accepted by the old-time population in those areas. It would seem that wholesome and potable are relative terms depending upon the standards to which the community is accustomed.

No attempt has been made to give statistical details. Although most of the operators of water supplies for larger communities in the state have permits for their water systems, many of the operators of small water supplies do not have them. The two conditions

that water systems must meet are that: [1] no water dangerous to health be supplied for human consumption, and [2] no person shall supply water unless he has a permit so to do. In the absence of sufficient personnel to attain both objectives, this department has expended primary effort to make certain that no unsafe water is served for domestic purposes. The success of this policy is demonstrated by the epidemiological record, which shows that there has been no major waterborne outbreak of disease in California since 1924. It is the department's opinion that a public health agency should not operate by police methods. Instead, the desired ends should be accomplished through education, so that compliance with public health objectives becomes a voluntary action by those who understand the importance of the objectives. In the past, the department has served primarily as a technical adviser to, rather than a supervisor of, the water works industry. The last session of the legislature, through a report by an assembly interim investigating committee and through amendments to the water permit act, however, expressed the desire that the department obtain full compliance with this law throughout the state. Efforts are therefore being made to require all water systems of the state to comply with the letter of the law by applying for permits. Permits are being granted to those systems that meet the standards established by the water permit law.

Procedure

Applications are made on forms which are available from the State Dept. of Public Health. For administrative purposes, two separate forms have been provided, one for municipalities, the other for individuals and companies. Information to accompany the application should include maps and plans, population to be served, water consumption figures and details on the source of supply, reservoirs and tanks, pumping stations, distribution system and operation and maintenance.

After an application is received from a water works operator, an investigation is made by department engineers into the sanitary features of the water system. This field check may include a survey of the watershed of a surface water supply, the sanitary surroundings of sources and other major features of the water system, a check of the bacteriological record of the water supplied and an examination of the operating procedures of the water works organization. After the information submitted in support of the application and the results of the field investigation are studied, recommendations are made to the State Board of Public Health. Most of these recommendations are favorable.

References

1. Laws and Standards Relating to Water and Water Systems and to Irrigation Districts. California Dept. of Public Health, San Francisco; *see also* California Water Supply Standards. Jour. AWWA **41**:1 (Jan. 1949).
2. Manual of Recommended Water-Sanitation Practice. Pub. Health Bul. 296. U.S. Pub. Health Service, Washington, D.C. (1946).
3. Sanitation Manual for Public Ground Water Supplies. Pub. Health Rpts., **59**:139 (Feb. 4, 1944).
4. Public Health Service Drinking Water Standards. Pub. Health Rpts., **61**:371 (Mar. 15, 1946); *see also* Jour. AWWA, **38**:362 (Feb. 1946).

APPENDIX

Laws on Domestic Water Supply

Excerpts from Div. 5, Part 1, Chapter 7, "Water and Water Systems," of the California Health and Safety Code, *1949; and from Chapter 2, "Powers (Irrigation District)," of Div. 11, Part 5 of the* Water Code.

Water and Water Systems

Article 1. Permits

Definitions

4010. "Person," as used in this chapter, includes any public utility, municipality, or other public body or institution.

"User," as used in this chapter, shall be defined to include any individual, corporation or association of individuals using water for domestic purposes, except that "user" shall not be defined to include any individual, corporation, or association of individuals processing water or selling, serving, furnishing, or supplying water to the public in any manner.

"Furnish or supply," as used in this chapter, is used in its normal and natural meaning, except that "furnish or supply" shall not be defined to include furnishing or supplying water to a user in a rural area for domestic purposes where the user receives the water, by pipe or otherwise, directly from an open irrigation canal system, but subject to foregoing, "furnish or supply" shall be defined to include furnishing or supplying water to two or more places of human habitation where said places are connected by an integrated pipe system owned and operated by the supplier.

4010.5. "Water Works Standards," as used in this chapter, means the "Standards of Minimum Requirements for Safe Practice in the Production and Delivery of Water for Domestic Use" adopted by the California Section of the American Water Works Association on October 29, 1948.* The board shall publish the Water Works Standards and make a copy thereof available upon request without charge to any person holding a permit under this chapter.

Permit to Supply Water

4011. No person shall furnish or supply water to a user for domestic purposes from any source of water supply, unless he first files a petition for permission so to do with the board and receives a permit as provided in this chapter.

4011.5. No person shall modify, add to or change his source of supply or method of treatment of water for domestic purposes as authorized by a valid existing permit issued to him by said board unless he first files a petition so to do with said board and receives an amended permit as provided in this chapter authorizing such modification, addition or change in his source of supply or method of treatment as may be specified in such amended permit, or unless such modifications, additions, or changes in the source of supply or method of treatment comply in all particulars with such of the mandatory requirements of the Water Works Standards as pertain to the quality of water supplied to consumers. Petitions for amended permits shall be made in accordance with the provisions of this chapter for the making of a petition for a permit as herein defined and shall be investigated, considered, determined and issued or denied upon the same terms and conditions as herein provided for the granting, issuing or denial of a permit as provided in this chapter.

4011.6. No person shall modify, add to or change his distribution system for

* See Jan. 1949 issue of JOURNAL, Vol. 41, No. 1.

water for domestic purposes as authorized by a valid existing permit issued to him by said board unless he first files a petition so to do with said board and receives an amended permit as provided in this chapter authorizing such modification, addition or change in his distribution system as may be specified in such amended permit, or unless such modifications, additions or changes in said distribution system comply in all particulars with such of the mandatory requirements of the Water Works Standards as pertain to the quality of water supplied to consumers. Petitions for amended permits shall be made in accordance with the provisions of this chapter for the making of a petition for a permit as herein defined and shall be investigated, considered, determined and issued or denied upon the same terms and conditions as herein provided for the granting, issuing or denial of a permit as provided in this chapter.

Plans and Specifications

4012. With the petition shall be filed a complete set of plans and specifications, together with a statement containing a general description and history of the existing or proposed plant, works, or system or proposed changes therein, and showing the geographical location thereof with relation to the source of the water supply and all the sanitary and health conditions surrounding and affecting such supply and the plant, works, or system.

4013. The plans, specifications, and statement shall be in such form and cover such matters as the board prescribes.

Investigation

4014. Upon receipt of a petition filed pursuant to this chapter the board shall make a thorough investigation of the proposed or existing plant, works, system, or water supply, and all other circumstances and conditions which it deems material.

Temporary Permit

The board may for good cause grant a temporary permit to any person who has filed a petition for a permit as provided in this chapter upon such terms as it shall determine are in the public interest pending the completion of the investigation required by this section of the proposed or existing plant, works, system or water supply, which temporary permit shall terminate upon the date therein specified. Said temporary permit may be revoked or suspended as provided in this code with respect to the revocation or suspension of a permit as provided in this chapter.

Hearing

4015. As a part of the investigation, and after 10 days' notice by mail to the petitioner, a hearing may be had before the board or an examiner appointed by it. At the hearing all testimony shall be given under oath, and evidence, oral and documentary, may be received, a record of which shall be made and filed with the board.

Petition Denial and Quality Change Order

4016. If, upon the completion of the investigation, the board determines, as a fact, that the water furnished or supplied, or proposed to be supplied is such that under all the circumstances and conditions it is impure, unwholesome, or unpotable, or may constitute a menace or danger to the health or lives of human beings, or the existing or proposed plant, works, system, or water supply, or proposed modifications, are unhealthful or insanitary, or not suited to the production and delivery of healthful, pure, and wholesome water at all times, it shall deny the petition and order the petitioner to make such changes as it deems necessary to secure a continuous supply of pure, wholesome, potable, and healthful water.

4017. *Repealed.*

Repairs

4018. The board may order such repairs, alterations, or additions to the existing plant, works, or system as to insure that the water furnished or supplied shall at all times be pure, wholesome, and potable, and without danger to the lives or health of human beings.

Change in Supply

4019. The board may order such changes in the source of the water supply or in the installation of purification and refining works and such other measures as shall insure a continuous supply of pure, wholesome, and potable water without danger to the lives or health of human beings.

Time of Change

4020. Any order requiring changes shall designate the period within which the changes are to be made.

A temporary permit may be issued by the board for the period fixed to permit the petitioner to comply with the order.

Permit

4021. If the board determines that the water being furnished or supplied is such that under all the circumstances and conditions it is pure, wholesome, and potable, and does not endanger the lives or health of human beings, it shall grant a permit authorizing the petitioner to furnish or continue to furnish or supply the water.

Revocation of Permit

4022. Any permit issued may be revoked or suspended by the board at any time if it determines that the water being supplied or furnished by the permittee is or may become impure, unwholesome, or unpotable or endangers or will endanger the lives or health of human beings.

Reports

4023. The holder of a permit may at any time by order of the board and upon demand be required to furnish to the board a complete report on the condition and operation of the plant, works, system, or water supply owned, operated, or controlled by him. The report shall be made by some competent person at the sole cost and expense of the holder of the permit.

Private Supply

4024. No permit is required of any person supplying water for domestic purposes on his own private property upon which there is no industrial camp, hotel, or temporary or permanent resort using the water.

Industrial Camps and Hotels

4025. The board, or any member of the department designated by the board to act in its behalf, or any local health officer may issue a permit for any water system supplying less than two hundred service connections or for any system supplying an industrial camp, hotel, or temporary or permanent resort.

Article 2. Violations

Inspection

4030. The board and its inspectors may at any and all reasonable times enter any and all places, property, enclosures, and structures for the purpose of making examinations and investigations to determine whether any provision of this chapter is being violated.

Impure or Unsuitable Water

4031. It is unlawful for any person to furnish or supply to a user water used or intended to be used for human consumption or for domestic purposes which is impure, unwholesome, unpotable, polluted, or dangerous to health.

Penalty for Violations

4032. Every person who knowingly violates or knowingly fails to comply with any of the provisions of this chapter, or of any order of the board issued pursuant to this chapter, or who procures,

aids, or abets in any such violation or failure, is guilty of a misdemeanor punishable by a fine not exceeding one thousand dollars ($1,000), or by imprisonment in the county jail not exceeding one year, or by both.

Continued Violation

4033. The continued existence of any violation of this chapter, or of any order of the board issued pursuant to this chapter, beyond the time stipulated for compliance with its provisions, constitutes a separate and distinct offense.

Public Nuisance

4034. Anything done, maintained, or suffered in violation of any of the provisions of this chapter is a public nuisance dangerous to health, and may be enjoined or summarily abated in the manner provided by law. Every public officer or body lawfully empowered so to do shall abate the nuisance immediately.

Injunction

4035. Any person who furnishes or supplies to a user water used or intended to be used for human consumption or for domestic purposes, without having an unrevoked permit so to do, may be enjoined from so doing by any court of competent jurisdiction at the suit of the board.

Water Code

Article 2. Water Distribution

Application

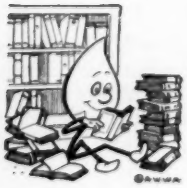
22264. The provisions of Chapter 7, Part 1, Division 5 of the Health and Safety Code shall not apply to districts except in specific areas concerning which the Dept. of Public Health gives written notice to the district.

Agriculture and Domestic Service

In areas where the service rendered by the district is primarily agricultural, and domestic service is only incidental thereto, the Dept. of Public Health may prescribe reasonable and feasible action to be taken by the district and the consumers to insure that their domestic water will not be injurious to health.

Utilities Not Excepted

Municipal and public corporations or utilities, other than a district, which distribute water within a district are not excepted from the provisions of Chapter 7, Part 1, Division 5 of the Health and Safety Code by this section.



Automotive Equipment Costs

By James B. Ramsey

A paper presented on April 30, 1951, at the Annual Conference, Miami, by James B. Ramsey, Chief Engr. & Supt., Water Dept., Kansas City, Mo.

THE cost of operating automotive equipment was recently surveyed in order to bring up to date the information collected by Geupel in 1941 (1). Questionnaires were sent to 56 utilities in United States cities of 100,000–200,000 population. A total of 24 usable replies (43 per cent), providing data for the calendar year 1950, were received. The questionnaires requested information for seven classifications of vehicles: total fleets, cars, ½–¾-ton trucks, 1-ton trucks, 1½-ton trucks, 2–3-ton trucks, and trucks of more than 3-ton capacity. The information requested for each classification was: number of vehicles; mileage; gas consumption; cost of gas; and annual costs for operation, maintenance, depreciation, and insurance. The utilities were also requested to state which of the following items were included among operating costs and which were included among maintenance costs: gas, oil, washing, grease, antifreeze, repairs, tires and tubes, batteries, and chains. Space was also provided for additional breakdown of items that the utilities might wish to include.

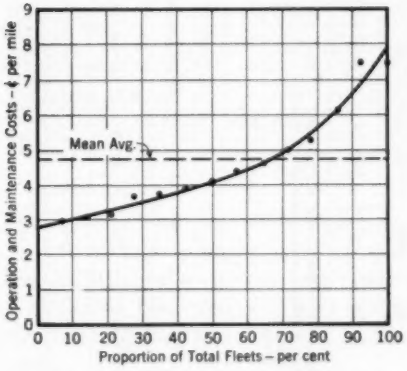

Operation and Maintenance Costs – ¢ per mile
Mean Avg.
0 1 2 3 4 5 6 7 8 9
0 10 20 30 40 50 60 70 80 90 100
Proportion of Total Fleets – per cent

Fig. 1. Cost-Frequency Curve for Entire Fleets

The fourteen fleets represented included 473 vehicles. The average cost was 4.74¢ per mile. Nine fleets had costs below this average, and five had costs above it.

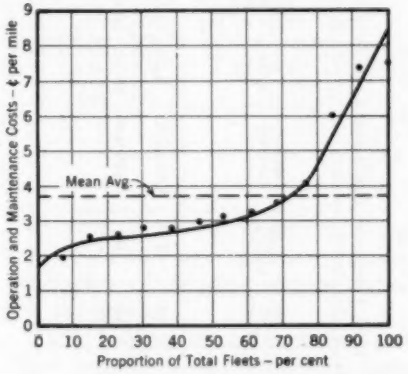

Operation and Maintenance Costs – ¢ per mile
Mean Avg.
0 1 2 3 4 5 6 7 8 9
0 10 20 30 40 50 60 70 80 90 100
Proportion of Total Fleets – per cent

Fig. 2. Cost-Frequency Curve for Cars

The thirteen fleets represented included 106 cars. The average cost was 3.70¢ per mile. Nine fleets had costs below this average, and four had costs above it.

TABLE 1

1950 Automotive Equipment Costs for Water Utilities in 24 U.S. Cities of 100,000–200,000 Population

Equipment	No. of Fleets	Total Vehicles	Distance Traveled *miles*	Gas Use *miles per gal*	Avg. Gas Cost *¢ per gal*	Opn. Cost *¢ per mile*	Maint. Cost *¢ per mile*	Total Opn. and Maint. Cost *¢ per mile*		Proportion for Maint.* *per cent*	Ins. Cost *¢ per mile*	Depn. Cost *¢ per mile*	Total Actual Cost *¢ per mile*	Ratio of Maint. to Opn.*
								At Given Price for Gas	At 20¢/gal for Gas					
Entire Fleets†	14	473	3,883,750	9.58	19.05	2.11	2.63	4.74	4.84	54	0.39‡	2.71§	7.84	1.19
Entire Fleets‖	10	390	2,859,939	10.39	18.00	—	—	6.44 (136% of 4.74	6.63 (137% of 4.84	—	0.64# (164% of 0.39	2.85# (105% of 2.71	9.93 (127% of 7.84	—
Cars†	13	106	1,038,315	13.30	19.05	1.53	2.17	3.70	3.75	58	0.29**	1.57#	5.56	1.36
½–¾-ton trucks†	14	188	1,741,730	10.38	19.05	1.93	2.41	4.34	4.44	54	0.37§	1.63#	6.34	1.19
1½-ton trucks†	11	90	508,342	7.06	19.05	2.99	3.52	6.51	6.44	55	0.66**	3.38#	10.55	1.21

* Operating costs adjusted for gasoline at 20¢ per gal.
† Fleets kept separate operation and maintenance records.
‡ Average of eight fleets.
§ Average of seven fleets.
‖ Fleets did not keep separate operation and maintenance records.
Average of five fleets.
** Average of six fleets.

TABLE 2

Distribution of Expenses by Fourteen Fleets

Distributed to:	Gas	Oil	Wash	Grease	Antifreeze	Repairs	Tires and Tubes	Batteries	Chains	License Fees	Paint	Garage and Rent
Operation	14	14	3	7	10	—	2	1	2	2	—	1
Maintenance	—	—	10	7	3	14	12	13	10	1	1	1

The questionnaire used was believed to be the simplest one possible for the managers of the various utilities to complete and still furnish the data necessary for the report. Results obtained with this form, however, indicate that future questionnaires should be designed to provide data on only the first three classes of automotive equipment—total fleets, cars, and ½–¾-ton trucks—instead of the seven classifications on this form. The types and uses of the heavier vehicles are so varied that comparative-cost data are of little value unless more detail is provided than that which is within the practical limits of a survey of this type.

TABLE 3

1950 Data on Entire Fleets of the 14 U.S. Cities with Separate Operation and Maintenance Cost Records

City	No. Vehicles	Distance Traveled *miles*	Gas Use *miles per gal*	Avg. Gas Cost *¢ per gal*	Opn. Cost *¢ per mile*	Maint. Cost *¢ per mile*	Total Opn. and Maint. Cost *¢ per mile*		Proportion for Maint. With Gas at 20¢/gal *per cent*	Ins. Cost *¢ per mile*	Depn. Cost *¢ per mile*	Total Cost Actual *¢ per mile*
							At Given Price for Gas	At 20¢/gal for Gas				
Canton, Ohio	27	243,732	9.48	17.50	1.13	1.83	2.96	3.22	57	0.41	1.93	
Charlotte, N. C.	20	202,330	8.30	22.00	2.74	1.71	4.45	4.21	41	0.45	—	
Corpus Christi, Tex.	41	260,567	8.68	19.00	2.37	2.53	4.90	5.01	50	0.55	—	
Des Moines, Iowa	32	299,936	8.61	15.86	2.33	5.17	7.50	7.98	65	0.23	1.38	
Fort Wayne, Ind.	58	351,765	8.15	20.10	2.62	3.49	6.11	6.10	57	0.64	—	
Grand Rapids, Mich.	45	316,130	9.96	15.00	1.65	3.02	4.67	5.18	58	—	—	
Jacksonville, Fla.	34	245,894	10.43	22.00	2.24	3.03	5.27	5.08	60	—	—	
Knoxville, Tenn.	41	374,651	8.71	12.56	1.61	2.14	3.75	4.61	46	0.18	2.72	
Little Rock, Ark.	29	271,365	10.42	26.00	2.66	4.88	7.54	6.96	70	0.18	2.63	
Nashville, Tenn.	23	217,082	11.86	18.00	1.60	2.20	3.80	3.98	55	—	1.48	
Peoria, Ill.	17	210,134	13.36	27.00	2.29	0.84	3.13	2.61	32	—	—	
Salt Lake City, Utah	60	547,161	10.37	21.00	2.14	1.67	3.81	3.71	45	—	—	
Tampa, Fla.	35	255,443	9.15	18.40	2.29	1.87	4.16	4.33	43	—	5.68	
Youngstown, Ohio	11	87,560	10.96	19.50	1.83	1.23	3.06	3.11	40	0.72	3.48	
TOTAL	473	3,883,750										
AVERAGE			9.58	19.05	2.11	2.63	4.74	4.84	54	0.39	2.71	7.84

Discussion of Data

The 24 usable replies fell into two distinct groups. Fourteen utilities reported itemized costs for maintenance and operation for each classification of equipment. Ten utilities reported only total costs for operation and maintenance for the entire fleet. Utilities in the latter group apparently did not keep costs of operation and maintenance separated, and, for the most part, they did not keep costs separated for the various classes of equipment. It is significant that the fourteen utilities that kept complete cost records showed substantially lower average costs per mile than the ten that did not keep complete records, despite a driving experience that averaged fewer miles per gallon of gasoline and a higher cost per gallon.

Table 1 shows the average costs and other data of the two groups of fleets and provides information on cars, ½–¾-ton trucks, and 1½-ton trucks, of the fourteen utiliites that kept complete records. The "averages" shown are means, or true averages. For example, the average cost per mile for opera-

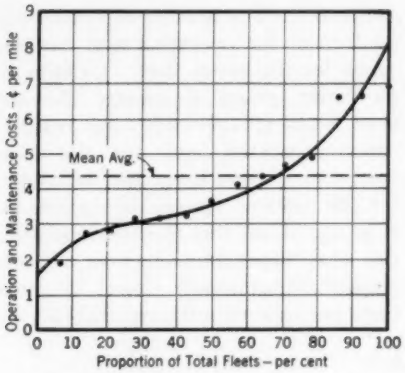


Fig. 3. Cost-Frequency Curve for ½–¾-Ton Trucks

The fourteen fleets represented included 188 trucks. The average cost was 4.34¢ per mile. Nine fleets had costs below this average, and five had costs above it.

tion was determined by dividing the total operating costs of all fleets or units by the total mileage they recorded.

The distribution of cost items to operation and maintenance expenses for the fourteen fleets that kept such records is shown in Table 2. The fourteen utilities agree completely only on the classification of expenses for gas, oil, and repairs. A trend one way or the other, however, is clearly indicated for all items except grease, which was classified as an operational expense by half the utilities and as a maintenance expense by the other half.

To show the variations in costs for the individual fleets, cost-frequency, or duration, curves were prepared as shown in Fig. 1–4. These curves reveal that two fleets had costs that were

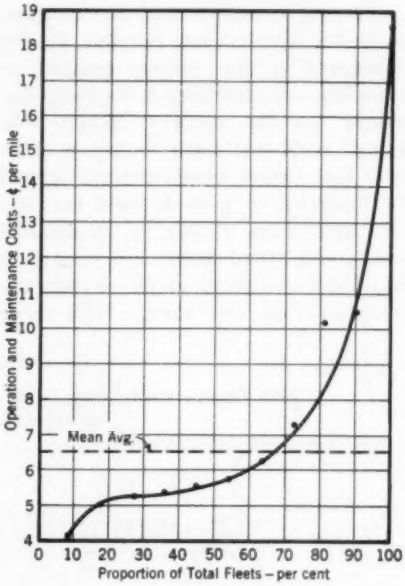


Fig. 4. Cost-Frequency Curve for 1½-Ton Trucks

The eleven fleets represented included 90 trucks. The average cost was 6.51¢ per mile. Seven fleets had costs below this average, and four had costs above it.

relatively high, and that these costs raised the average to a point at which 70 per cent of the fleets had costs that were less than average.

The names of the cities served by the fourteen utilities mentioned in this report and the cost data for their total fleets are contained in Table 3.

Reference

1. GEUPEL, LOUIS A. The Control of Automotive Equipment. Jour. AWWA, **33**: 1362 (Aug. 1941).

Design and Construction of Impervious Membranes for Excavated Reservoirs

By James W. Trahern

A paper presented on Oct. 26, 1951, at the California Section Meeting, San Francisco, Calif., by James W. Trahern, Supervising Civ. Engr., East Bay Municipal Utility Dist., Oakland, Calif.

AN examination of general experience in the operation of existing reservoirs in excavations reveals the occurrence of much trouble from leakage. Great amounts of money are continually being spent by water works organizations both to stop this leakage and to pay damages resulting from it.

The East Bay Municipal Utility Dist. has experienced the same leakage problems that face many other water works operators, and has found it necessary to abandon several small reservoirs, because leakage from them was causing damage. Many years ago, small water companies constructed these reservoirs in undeveloped areas. Nearby properties were subsequently developed and incurred serious damage. As property development progressed, expensive reconditioning and repairs to several larger and more costly reservoirs were necessary because of leakage damage. The district's insurance carriers have several times been required to make payments to property owners for major damages from reservoir leakage. It is generally justifiable, therefore, to spend large sums to construct new reservoirs that are substantially watertight.

Regardless of the type of lining used, reservoirs excavated in consolidated clay or other impervious natural material will be tight. In the San Francisco Bay area and in many other areas of the country, however, impervious earth formations are not prevalent nor dispersed suitably to permit their use in construction of required water storage reservoirs. It is often desirable, therefore, when constructing new reservoirs in excavation, to provide an underdrain system and a tight lining for leakage control.

Long and varied experience indicates that carefully constructed concrete reservoir linings are not always satisfactorily watertight. Engineering publications are filled with accounts of costly operations undertaken to make leaking reservoirs tight, although these reservoirs had been furnished originally with carefully designed and carefully constructed concrete linings. The final cost of the reconditioned reservoir has usually exceeded the cost which would have been required for the same reservoir had it originally been equipped with underdrains and a tight lining. Many reservoirs have been abandoned after costly efforts to repair them have proved unsuccessful.

Seneca Reservoir

The Seneca Reservoir, recently put into operation by the East Bay Municipal Utility District, was constructed to a unique design. The design was calculated to provide satisfactory water-

tightness and thorough leakage control at comparatively low cost. After eight months of operation, the measured discharge of the underdrain system is extremely low. The cost of the reservoir lining and conventional features to produce watertightness was low—approximately $3,000 per mil gal. There are excellent indications at this time that the unique design of the reservoir has merit.

Seneca Reservoir, a 30-mil gal distribution reservoir, is located on a knoll in East Oakland, Calif. It is the third largest reservoir in the distribution system of the East Bay Municipal Utility Dist. It is 600 ft long, 445 ft wide, and 28.5 ft deep below flow line. The water-surface area at full reservoir is 5 acres. The total cost of the completed reservoir, exclusive of property, was $390,539.36. The unit cost was approximately $13,000 per mil gal. Rough excavation of 320,000 cu yd was performed at no cost to the district, as the excavated material was used in constructing revetments at Oakland Airport at the beginning of World War II. Had this excavation been done at district expense, the total cost of the reservoir would have been approximately $550,000; the unit cost, approximately $18,300 per mil gal. The cost of features producing watertightness was 16 per cent of the normal total cost of the reservoir.

The reservoir is located in an exceedingly pervious rock formation which is soft and was easily excavated with ordinary equipment. The formation was severely fractured by major earth movements in the past. Rain water that fell into the rough excavation quickly disappeared into the earth and reappeared in springs at the foot of the knoll, 150 ft below the reservoir. These springs have not reappeared since the reservoir started operating.

Fig. 1. Aerial View of Seneca Reservoir

Unique Design Features

From the beginning, the need for construction of a watertight lining as

well as a positive underdrain system was obvious. Compacted clay, in substantial thickness, was the lining most generally used in the past to produce watertightness successfully. To haul this material to Seneca Reservoir and compact it would have been costly. It was thought that a thin, flexible membrane of impervious material, constructed on a firm and smooth foundation, might meet the requirements for a watertight reservoir. It was finally decided, therefore, to use an asphalt membrane on a constructed firm base. The essential features finally selected to provide leakage control were:

1. A seal coat, consisting of a spray coat of emulsified asphalt dusted with sand, on the subgrade of the reservoir

2. A positive underdrain system consisting of tile drains located in trenches at the bottom of the reservoir, and a gravel blanket $2\frac{1}{2}$ in. thick on the bottom and sloping banks (The drains were extended to discharge into a concrete structure located outside the reservoir.)

3. A compacted base, 4 in. thick, of rock aggregate stabilized with emulsified asphalt, over the gravel blanket (The base material was mixed in a pugmill and compacted with rollers.)

4. An impervious membrane of reinforced asphalt over the compacted base, $\frac{3}{16}$ in. thick on the sloping banks and $\frac{1}{4}$ in. thick on the reservoir floor (This tough, flexible reinforced membrane was constructed of an asphaltic emulsion containing asbestos fiber and was applied by spraying.)

5. A 4-in. concrete slab over the impervious membrane, reinforced with steel bars on the reservoir banks but not on the bottom (Contraction joints were constructed in the concrete lining at 12-ft intervals in both directions on the bottom and at approximately 12-ft intervals in one direction on the banks. On the banks, the joints follow the slope from bottom to top. The

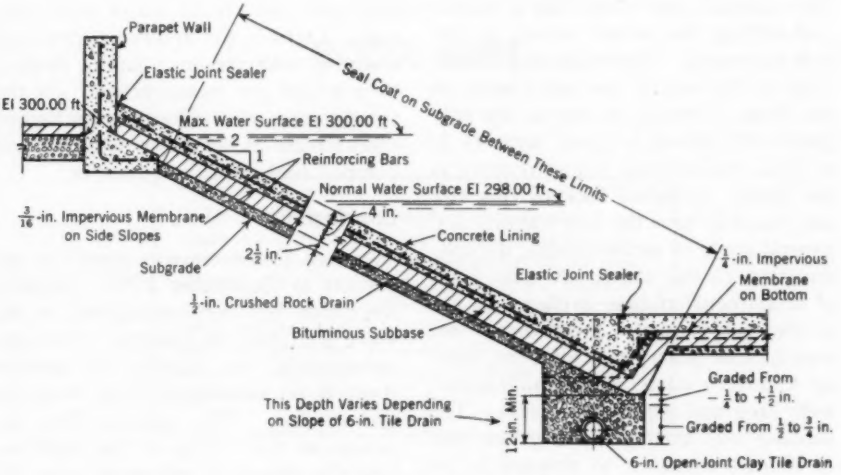


Fig. 2. Typical Section of Lining

This cross section indicates the pertinent details of design.

contraction joints were all sealed with a latex and asphalt emulsion.*)

A general view of Seneca Reservoir is shown in Fig. 1, and a typical section of the lining, shown in Fig. 2, indicates the pertinent design details.

Construction Details

Lining on the 2:1 slope at Seneca begins with the rolled and stabilized subgrade which consists of dry, porous earth, and has a small outcrop of rock at one end. When sprayed with water, this material acts much like a blotter —absorbing the water before it collects as runoff. Approximately 12,000 sq yd of this earth was seal-coated on the slope. Directly on top of the subgrade was placed a 2½-in. layer of ½- to ¾-in. crushed-rock lining to serve as the drain. Crushed rock of this size was found to have the best stability and natural angle of incline during the construction of the slope. A 4-in. layer of bituminous subbase is placed on top of the rock blanket. More than 1,900 tons of this quarry-run material, similar to quarry waste, was pugmill-mixed with lime and asphalt emulsion. The subbase was then given a prime coat of diluted emulsion to prepare it for the membrane.

Directly over the subbase, the impervious membrane, a $\frac{3}{16}$-in. layer of asbestos-fiber-bound asphalt emulsion,† is built up to specified thickness by spraying. The top layer of the reservoir lining is a 4-in. slab of Class A concrete, reinforced with ⅜-in. bars on 1-ft. centers. Reinforcing steel does not extend through contraction joints.

The multilayered lining for the floor differs slightly from that on the slope. A heavier, ¼-in. membrane is used between subbase and concrete, and no reinforcing steel is used in the floor slab. Reinforcing steel was provided in the slopes to prevent downhill creep, a characteristic of inclined concrete slabs that are exposed to normal temperature expansion and contraction.

All drainage water is collected by a 6-in. tile drain and gravel trench around the perimeter of the reservoir floor. An additional tile drain and trench lies in the center of the reservoir floor and collects all water from that area. Outside the reservoir, drainage water is collected in a sump, flowing over a weir for measurement. At the sump, water can either be discharged downstream as waste or collected and pumped back into the structure.

Conclusions

Seneca Reservoir was placed in operation in September 1950. Regular inspection has been maintained to observe and measure leakage. After approximately ten months of service, there is no measurable flow from the underdrains. The springs that appeared at the bottom of the knoll below the reservoir whenever rain fell into the excavation for the reservoir have not reappeared. The new design for the reservoir has so far proved fully as successful as was expected.

On the basis of experience with the Seneca Reservoir, the district is now planning the construction of several other large reservoirs of the same general design within the near future. In subsequent reservoirs of this type the side slopes will be established at 2½:1 instead of 2:1 to facilitate installation of the stabilized base material and the gravel blanket. Otherwise, no important design changes have been contemplated.

* "Joint Seal," a product of Industrial Asphalt Co., Berkeley, Calif.

† Laykold Weathercoat," a product of American Bitumuls & Asphalt Co., Oakland, Calif.

AWWA
B201-51T

American Water Works Association

Tentative

STANDARD SPECIFICATIONS

for

SODA ASH

These "Tentative Standard Specifications for Soda Ash" are based upon the best known experience and are intended for use under normal conditions. They are not designed for use under all conditions and the advisability of use of the material herein specified in any water treatment plant must be subjected to review by the chemist or engineer responsible for operations in the locality concerned.

Approved as Tentative by the Board of Directors of the AWWA
on October 15, 1951

First Printing, February 1952

AMERICAN WATER WORKS ASSOCIATION
Incorporated
521 Fifth Avenue, New York 17, N.Y.

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These "Tentative Standard Specifications for Soda Ash" were prepared under the direction of C. K. Calvert (deceased) and J. E. Kerslake of the Water Purification Division, AWWA. The specifications were approved by the Executive Committee of the Water Purification Division and by the Water Works Practice Committee, and received the approval of the Association's Board of Directors on July 1, 1949. The specifications were also submitted for review to producers and consumers of the materials involved, whose comments were then considered by R. C. Bardwell, acting as referee. The text as finally edited was approved by the Executive Committee of the Water Purification Division on February 23, 1951, and was reaffirmed by the Board of Directors on October 15, 1951.

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Tentative

Standard Specifications for Soda Ash

Part A—Material Specifications

Sec. 1A—Scope

These specifications cover soda ash for use in the purification and softening of municipal and industrial water supplies. The specifications are intended for use with Part B (Sampling, Inspection, Packing, and Marking) and Part C (Testing Methods) of this document.

Sec. 2A—Definition

The name "soda ash" is a commercial designation of anhydrous normal sodium carbonate. It is not to be confused with sal soda which is of almost the same chemical composition except that it contains water of crystallization and, consequently, does not contain as much sodium carbonate per unit of weight.

Sec. 3A—Sampling

Sampling shall be conducted in accordance with Part B (Sampling, Inspection, Packing, and Marking) of this document.

Sec. 4A—Methods of Testing

The laboratory examination shall be carried on in accordance with Part C (Testing Methods) of this document.

Sec. 5A—Impurities

The soda ash supplied under these specifications shall be free from chips or other foreign matter and shall contain no soluble mineral or organic substances in quantities capable of produring deleterious or injurious effects upon the health of those consuming the water which has been treated properly with the soda ash.

Sec. 6A—Rejection

6A.1. Notice of dissatisfaction with a shipment, based on the specifications, must be in the hands of the consignor within ten days after receipt of the shipment at the point of destination. If the consignor desires a retest, he shall notify the consignee within five days of the notice of the complaint. Upon receipt of the request for a retest, the consignee shall forward to the consignor one of the sealed samples. In the event that the results obtained by the consignor, on retesting, do not agree with the results obtained by the consignee, the other sealed sample shall be forwarded, unopened, for analysis, to a laboratory agreed upon by both parties. The results of the referee shall be accepted as final, and the cost of the referee analysis shall be paid for by the party whose results show the greatest deviation from the referee analysis.

6A.2. On the basis of the retest or the referee test, the consignor may remove the material from the premises of the consignee, or a price adjustment may be agreed upon by the consignor and consignee.

Sec. 7A—Size

The material shall be a dry white powder containing no large lumps or crystals and shall be "free flowing" and suitable for storage in closed hoppered bins and for feeding in dry-feeding machines.

Sec. 8A—Sodium Oxide Content

The material as delivered shall contain not less than 98 per cent by weight sodium carbonate (Na_2CO_3), of which not less than 58 per cent shall be in the form of sodium oxide (Na_2O).

Sec. 9A—Insoluble Matter

The insoluble matter shall not exceed 0.05 per cent.

Sec. 10A—Density

The specific gravity of light soda ash shall range between 0.4 and 0.5. (Dense granular soda ash has a specific gravity between 0.94 and 1.05.)

NOTE: No limit has been set for ammonia. It is not felt that this is necessary as the normal commercial grade of soda ash contains 99 + per cent of anhydrous sodium carbonate. If ammonia were present, higher chlorine doses would have to be used when treating water, so as to provide an active residual chlorine content. If such treatment is being used and plant tests show that above normal chlorine doses are required, a limitation on the amount of the ammonia should be added to the specifications.

Part B—Sampling, Inspection, Packing, and Marking

Sec. 1B—Scope

These procedures for the sampling, inspection, packing, weighing, and marking of soda ash are intended for use with Part A (Material Specifications) and Part C (Testing Methods) of this document.

Sec. 2B—Sampling

2B.1. Samples shall be taken at the point of destination.

2B.2. If the soda ash is handled by conveyor or elevator, a mechanical sampling arrangement may be used.

2B.2.1. With packaged material, 5 per cent of the packages shall be sampled. No sample shall be taken from a broken package.

2B.2.2. Soda ash may be sampled from carload shipments in bulk or from packages by the use of a sampling tube at least ¾ in. in diameter.

2B.3. The gross sample, weighing at least 10 lb, shall be mixed thoroughly and quartered to provide three 1-lb samples. They shall be sealed in airtight, moistureproof, glass containers. Each sample container shall be labeled for identification and be signed by the sampler.

Sec. 3B—Packing and Shipping

3B.1. Soda ash may be shipped in bulk; in bags of 100, 150, 200, and 300 lb; or in barrels of 275 or 300 lb net weight, as specified.

3B.2. The net weight of packages shall not deviate from the recorded weight, plus or minus, by more than 2.5 per cent. If exception is taken to the weight of the material received, it shall be based on a certified unit weight of not less than 10 per cent of the packages selected at random from the entire shipment.

Sec. 4B—Marking

Each shipment of material shall carry with it some means of identification. Each package shall be legibly

marked with the net weight of the contents, the name of the manufacturer, and a brand name, if any. The package may bear, also, the statement "'Guaranteed' by (name of manufacturer) to meet the specifications of the American Water Works Association for soda ash."

Part C—Testing Methods

Sec. 1C—Scope

These methods for the examination of soda ash are intended for use with Part A (Material Specifications) and Part B (Sampling, Inspection, Packing, and Marking) of this document.

Sec. 2C—Sampling

2C.1. Sampling shall be conducted in accordance with Part B (Sampling, Inspection, Packing, and Marking) of this document.

2C.2. The sample delivered to the laboratory shall be quartered into units of approximately 100 g. After thorough mixing, store this sample in an airtight glass container and weigh out of it rapidly to avoid change in moisture content.

2C.3. The laboratory examination of the sample shall be completed within five working days of receipt of the shipment.

Sec. 3C—Apparent Specific Gravity

3C.1. Pour, without packing, 30 g of the sample into a 100-ml graduated cylinder. Read the volume occupied by this sample.

3C.2. *Calculation:*

$$\frac{30}{\text{ml of sample}} = \text{specific gravity.}$$

Sec. 4C—Insoluble Matter

4C.1. Add 10 g of the sample to approximately 200 ml of distilled water in a 400-ml beaker, bring to boil, and continue boiling for 10 min.

4C.2. Filter through a weighed Gooch crucible, wash thoroughly, dry at 100–105C. Cool, desiccate to constant weight, and weigh.

4C.3. *Calculation:*

$$\frac{\text{Weight of insoluble residue}}{\text{Weight of sample}} \times 100 = \text{per cent of insoluble matter}$$

Sec. 5C—Total Available Alkali

5C.1. *Reagents:*

5C.1.1. 0.1*N* hydrochloric acid.

5C.1.2. Methyl orange indicator.

5C.1.3. Phenolphthalein Indicator.

5C.2. *Procedure:*

5C.2.1. Weigh 1.325 g of the sample and transfer to a 500-ml, glass-stoppered volumetric flask partly filled with distilled water. After solution is complete, add distilled water to make the total volume 500 ml, and mix thoroughly.

5C.2.2 Titrate 50 ml of the solution (5C.2.1) with 0.1*N* hydrochloric acid, using phenolphthalein and methyl orange indicators. First add the phenolphthalein indicator and titrate until the pink color disappears. This will give the approximate halfway point. Then, when most of the hydrochloric acid has been added, boil 2 min; cool thoroughly, and complete the titration to the methyl orange end point. (This procedure will remove most of the carbon dioxide and give a sharper end point.)

5C.3. *Calculation:*

$$\text{ml hydrochloric acid used} \times 4 = \text{per cent } Na_2CO_3.$$

5C.3.1. Multiply by 0.5849 to obtain the equivalent per cent of sodium oxide (Na_2O).

5C.4. If an examination of the sample indicates less than 98 per cent sodium carbonate, the bicarbonate test may be applied in accordance with the directions in Sec. 5C.5, and such correction made as the determination indicates.

5.C.5. *Bicarbonate Correction.* Dissolve 8.4 g of the sample in 50 ml of carbon-dioxide–free distilled water and titrate with 1.0*N* sodium hydroxide until a drop of the solution added to a drop of freshly prepared silver nitrate indicator on a spot plate produces a dark color instantly.

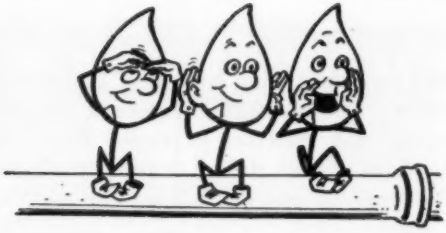
5.C.5.1. *Calculation:*

$$\frac{\text{ml } 1.0N \text{ NaOH} \times 8.4}{\text{Weight of sample}} = \text{per cent } NaHCO_3$$

Total alkali as per cent Na_2CO_3

= (per cent $NaHCO_3 \times 0.6309$)

= per cent Na_2CO_3 net.



Percolation and Runoff

The big wheels ain't round no more! They've all gone home, now that the AWWA Board of Directors meeting, held this year in New York's Park-Sheraton Hotel on January 13–16, is, as of this writing, over. While they were here though—the 97.5 per cent of the Board who showed up—they really worked, beginning on Sunday and plugging hard to finish on Tuesday in time to attend the New York Section luncheon meeting at which they were guests of honor. What of major moment they accomplished you either already know from the January 31 report "to all members" or you'll find out from the administrative reports in next month's JOURNAL. But they had their minor moments, too—even if those had to be squeezed in between sessions or after the midnight oil had been kindled. Of course, a considerable amount of hilarity didn't wait for the Sunday night dinner schedule or the Monday night off. We understand that even the balloting for officer nominees was attended by a considerable amount of "have-you-hearding" that wasn't strictly to the point and, having been present when Doc Berry received a tie that he will wear only with a vest, we can assure you that the Board won't be bored. The fact that we have so little to tell here is partly because our spy system failed in a pinch or two, partly because there was too much work to do, and still partlier because ladies may be present. Besides, something ought to be left for a Director to report, something that will probably permit your big wheels to roll *you* in the aisles!

Speaking of rolling, though, brings us back to a subject that *may* be getting boring by now—steel, that is, and the shortage of scrap that, by the beginning of the year, had already caused a shutdown of eight open-hearth furnaces and was threatening 50 to 100 more. From furnaces to rolling mills to civilian products is the path of scarcity. The weather has played a part in threatening to reduce our steel production 10 per cent, but only because scrap inventories have been so depleted has the delay of shipments by bad weather had so serious and immediate an effect. Start your scrap rolling now by selling it to your local scrap dealer.

(Continued on page 2)

(*Continued from page 1*)

"Necessary supplies of alum for public water treatment" are among the essential uses of sulfur and sulfuric acid specifically "supported" by the Defense Production Administration, and therefore exempted from the amendment to NPA order M–69, which restricts the use of sulfur to 90 per cent of the use during 1950. The previous limit was 100 per cent of 1950 use.

Al Kharj in Saudi Arabia is no friend of ours; Al is a place—a place that's particularly interesting for the three 1,000-acre experimental farms that flourish there, producing, right out in the middle of the Arabian desert, a full forty crops including everything from eggplant to alfalfa. Imagine farming anywhere at a profit, much less netting a handsome 25 per cent out of an overgrown sand trap. Of course there's a catch to it. Water! And water works!

Actually, the water has always been at Al Kharj, but because the larger of the two natural open-pit wells that makes it an oasis was practically inaccessible, because the smaller of them provided enough water for ordinary needs, and because going to a lot of trouble to get water to pour on a desert didn't seem sensible anyway, no one worried about the whole thing until recently, when the Saudi Arabian government, mixing its liquids, commissioned the Arabian American Oil Co. to undertake the project.

Aramco perched a pumphouse on a precipice, dropped a hose a hundred-some feet straight down to reach water, and has been pumping 12,000 gpm, 24 hr per day, out into the desert ever since through open irrigation ditches. And ever since, too, King Ibn Saud's royal household has been well fed with not only fresh vegetables, but even more prized fresh chicken and fresh eggs.

Al, however, is a lot farther away than you have to go to get just as good examples of the wonders of water. Ask oil-rich Texas, for instance, about its most important resouce and it'll be water that's discussed. Only a month ago, the Fort Worth *Star-Telegram* editorially pointed out that water more than anything else will be the limiting factor in the state's industrial expansion. Ask copper-rich Arizona about its most important resource and again water will be the answer—water to make the citrus grow, water to concentrate the low-grade copper ore, water for the copper extraction process, and water soon, now, for manganese mining too. Ask climate-rich Southern California about its most important resource and you'll learn it's rain. Water has long been king in California, and fifteen years of drought just passed have done little to reduce its hold on the position.

Perhaps too bad that water has to play hard to get to be appreciated. But then, it doesn't have to worry about losing out. Not with Al—or any other.

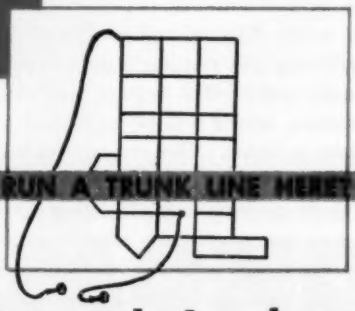
(*Continued on page 4*)

Wouldn't You Like to KNOW? - in Minutes instead of Days?

Where is the bottleneck?

What is corrosion doing to our flow?

Which plan is best?



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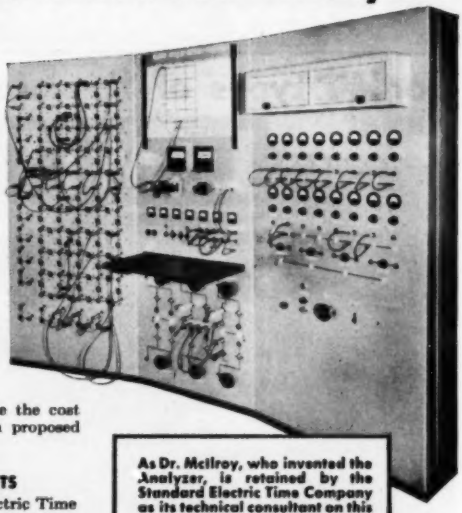

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(Continued from page 2)

Better go to night school! The head start you get there ought to help you get the new job in a new field that you're going to need any day now as the public water supply business quickly obsolesces. Of course, the fact that there are still a few outhouses in existence holds hope that at least a few of you will be able to stick to your trade for some time yet, but don't count on it. If we take the word of Charles Eames, designer of the chair that is "the sitting sensation of modern design" and radical thinker in the field of domestic engineering, the home of the future will use water only for waste disposal and will be equipped with its own closed supply system, purifying and reusing a gallonage related to its cubage. Industrial water supply might offer some of you some shelter, but the bottled drinking water business which will be expanded to fit the future ought to make you feel more at home. Better yet, you might start developing one of those pneumatic devices which Mr. Eames predicts will take the place of washing, as a more sanitary way of getting the flesh clean. Our imagination runs riot, not so much with the idea of vacuuming our teeth as with tracing public waterlessness to pipelessness to purification plantlessness to sourcelessness —even to senselessness—but we'd sure like to sit in an "Eames chair."

(Continued on page 6)

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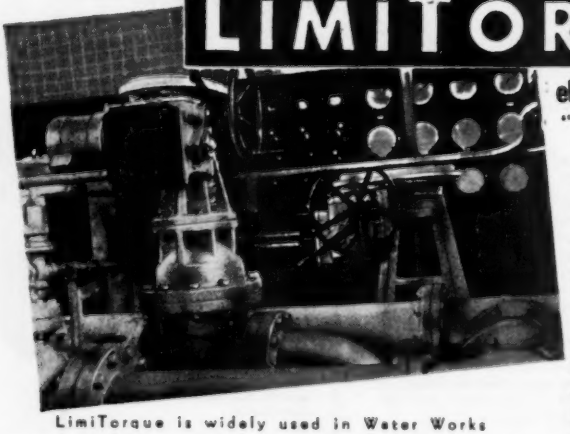

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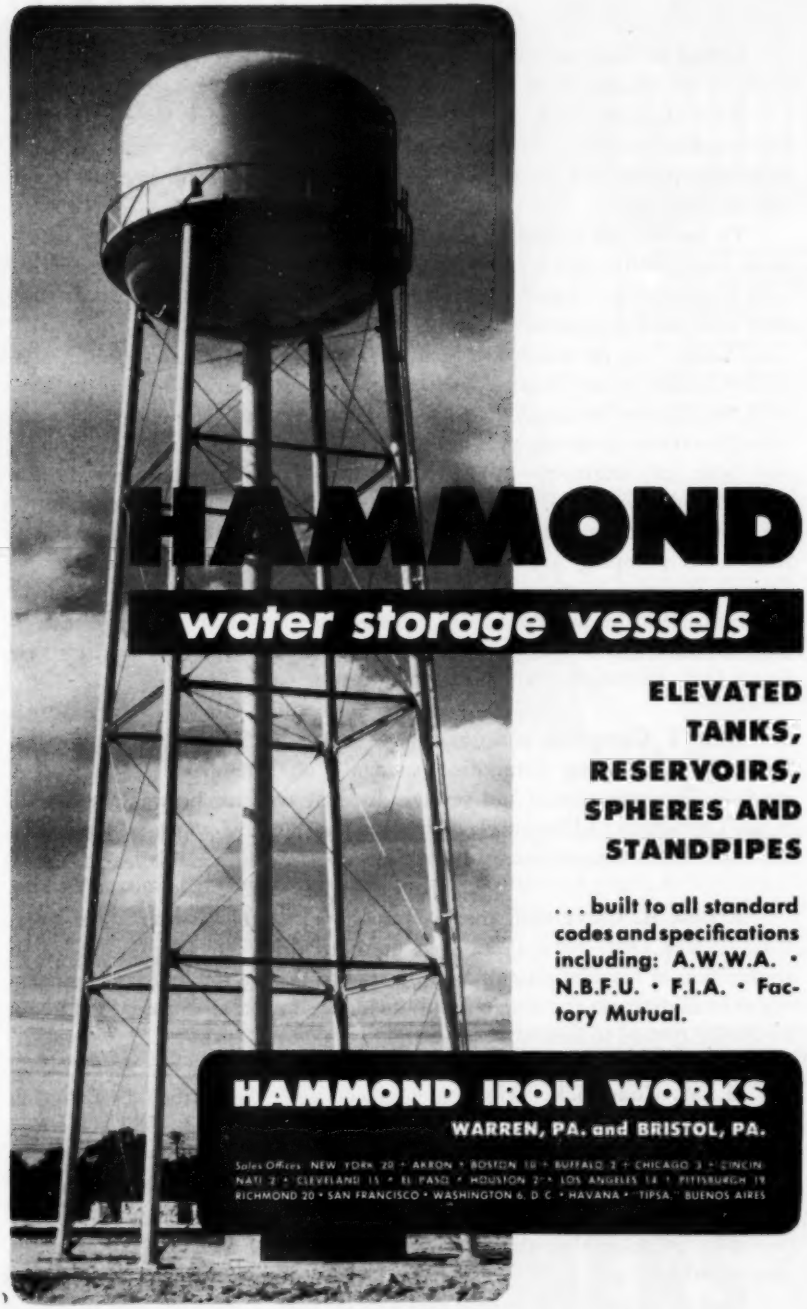
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(*Continued from page 4*)

Loran D. Gayton, 67, formerly Chicago City Engineer, passed away suddenly on December 28, 1951, in his home in Chicago.

After attending high school he came West and entered the employ of a construction company. He became a construction engineer, building such structures as viaducts, dams, and one of the first reinforced concrete buildings in Chicago.

To further his technical education he attended the University of Illinois from 1910 to 1913, and received the degree of Bachelor of Science in Civil Engineering. Later, on the basis of postgraduate work, he was honored with the Professional Degree in Civil Engineering.

"Larry," as he was affectionately known, spent his adult life in the service of the city of Chicago. In 1913 he became a draftsman in the Div. of Water Works Design of the Bureau of Engineering. He moved upward through various positions until he became engineer of water works design, and, later, city engineer—a position he held, with the exception of a few years, from 1927 to 1941. He had charge of the design and construction of the Chicago Avenue Lake and Land Tunnel, the William E. Dever Crib and such water pumping stations as Western Avenue, Thomas Jefferson and Cermak Pumping Stations.

Since 1941 he had the title of assistant city engineer in charge of construction, and was in charge of the design and construction of the city's new South Dist. Filtration Plant through the substructure stage.

John T. Campbell, consultant and partner in The Chester Engineers, Pittsburgh consulting firm, died suddenly on December 24, 1951. A specialist in water supply and sewage disposal systems, he was a graduate of the University of Pittsburgh (1910) and at one time was associated with the city's water department.

Ernest A. Cleveland, chief commissioner of the Greater Vancouver, B.C., Water Dist. since 1926, died quite suddenly on Jan. 8, 1952. In recognition of his administrative leadership to the district and his engineering contributions to the water supply field, the Canadian Section had given its Fuller Award to him in 1946.

H. M. Chadwick, irrigation engineer with the Armco Drainage & Metal Products Corp., died in Berkeley, Calif., on Jan. 22, 1952. He was 63 years old.

A member of the Steel Water Pipe Manufacturers Technical Advisory Committee, he was active in its work since its organization in 1941, and thus contributed to the preparation and formation of the Association's steel pipe standards.

(*Continued on page 8*)

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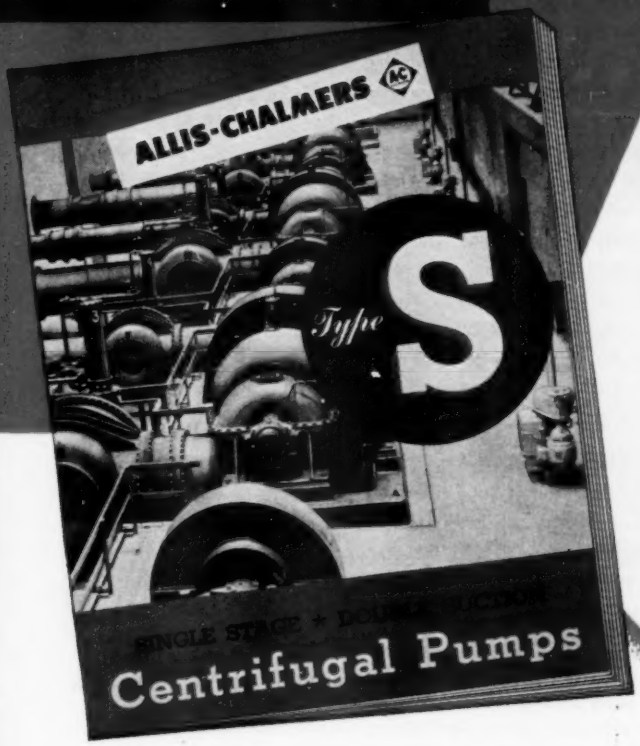

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(*Continued from page 6*)

What price water? is getting new answers in more and more places all the time as water works men try to keep not up to but in sight of price levels for anything else. Recently, for instance, Kansas City, Mo., boosted its rates approximately 17½ per cent while Dallas, Tex., put through a 20 per cent increase. But what really convinces us that the trend is extended is word of the Comptonville, Calif., Township Water Service's request for its first price hike—an increase that will add 30 cents to the present $1.10 per month charge for all the water you can carry home in a bucket from the Comptonville town pump. Of course, the town has a piped water supply, too, serving some of its 48 accounts, and proposes to increase the present flat rate of $2.20 to $2.75 for such de luxe service. What pricked our trend bubble, however, was the information that the increase was required because the county health department had ordered the town to install a chlorination system—cost approximately $1,500, almost half the system's net earnings during the past eight years. What price water?

"There ought to be a law!" And the Virginia Legislature is going to have an opportunity to enact it as a result of dogbite No. 8 on the leg of Norfolk postman C. L. Gwynn. Slow to anger, Mr. Gwynn promises now, after 37 years of delivering mail, that he'll wring but once if No. 9 threatens. But he wants, too, to penalize the owners of biters of postmen and of others subject to the same hazards. Meter readers have been first to rally to his aid, with the slogan: "We're With Gwynn; We Won't Bear It!"

R: "Bow-Wow, Mister Meterman!," a publication of AWWA, 5¢ a copy.—*Advt.*

Ohio examinations for operator certification in water and sewage treatment are to be held on April 25 in five cities in that state. Details and application blanks may be obtained from G. A. Hall, secretary of the Advisory Board of Examiners, Ohio Dept. of Health, 306 Ohio Departments Bldg., Columbus 15. March 10 is the closing date for filing applications, which must be submitted on forms supplied by the board.

(*Continued on page 10*)

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(*Continued from page 8*)

20,000 wormy snails, 25,000 wormy mice, and one worm scientist, all working together at Pearl River, N.Y., are a combination out to lick schistosomiasis, a disease which afflicts some 144,000,000 people, mostly in the tropics. Since the cercaria of the worm which causes schistosomiasis may be present in water supplies exposed to contamination by those returning from the tropics, it behooves us to cheer on all 45,001 of them in their present search for a compound that will be successful for treating the disease. To date, Dr. Redginal Hewitt, whose worm science previously perfected the drug hetrazan to treat elephantiasis, has already spent three years, 5,000 compounds and $200,000 in his search, conducted at the Lederle Laboratories in Pearl River. Because of the complicated life cycle of the parasitic schistosome, which requires two hosts, or—at his rate of progress, approximately 800 per week—Dr. Hewitt figures that this may be only the beginning. It's obvious which of the collaborators sets the pace.

The mountain has come to Mohammed—unasked, too, and certainly unexpected, but welcome nonetheless. N. Subbiah is our mountain's name—N. Subbiah of Thadikombu P.O., Dindigul, South India. And what's mountainous about old N. is the fact that his title is "Water Diviner." Who could more surprise us with a request for information regarding radar and other new types of ground water exploration equipment? Of course this may be mere snooping into competitor's secrets or seeking ammunition for argument, but even if it isn't a clear-cut coming, this must be classed as a move in the right direction.

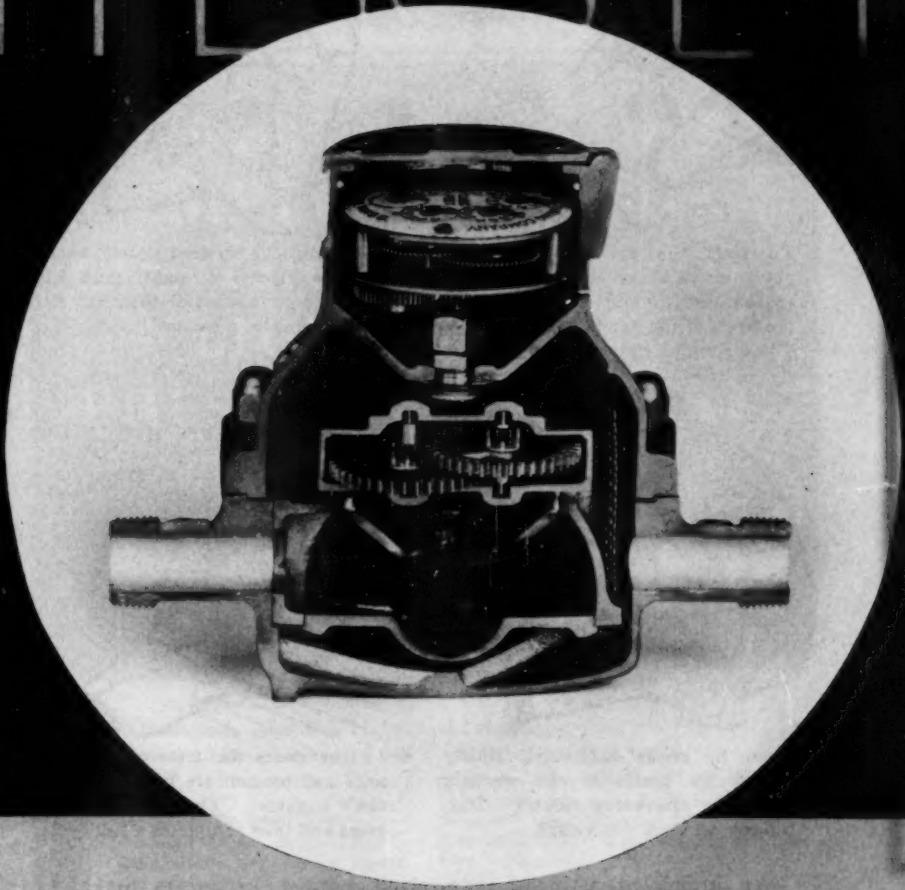
Too bad the area around Kenneth Roberts' and Henry Gross' headquarters at Kennebunkport, Me., is not more mountainous.

The Stuart Steel Protection Corp. (Stepco) has been formed by Linden Stuart as chairman of the board and Linden Stuart Jr. as president. The senior Stuart was for long the manager and president of the Wailes Dove-Hermiston Corp. (now a part of the Koppers Co.). Linden Stuart Jr. was most recently connected with the Barrett Div., Allied Chemical & Dye Corp.

The Republicans are in! And you can thank dowser Marcel Triau of Canaan, N.Y., for making it a sure thing. It was Marcel, you see, who applied his chain-twitch method of water divining to the location of Williams College's buried elephant. And now that students have started digging where he felt the vibrations, it's only a matter of time before the six-ton behemoth, donated dead to the College's Biology Museum by a traveling menagerie in 1851 and buried then to deflesh the skeleton, is exhumed. What bigger symbol can you want?

(*Continued on page 12*)

HERSEY



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(Continued from page 10)

1. To start the cycle the operator places his hands on the victim's back so that the thumbs just touch and the heels of the hands are just below a line running between the armpits.

2. He then rocks forward slowly, keeping the elbows straight, until his arms are approximately vertical, exerting steady pressure upon the chest.

3. Then he rocks backward, slowly sliding his hands to the victim's arms just above the elbows. Continuing to rock backward, . . .

4. . . . he raises the arms until resistance and tension are felt at the victim's shoulder. Then he drops the arms and thus completes a full cycle.

An improved artificial respiration method, known as the back-pressure arm-lift, has been adopted by the American Red Cross, the armed forces, Public Health Service, and a number of other agencies and industrial firms. The superiority of the new method—which is illustrated above—to the old prone pressure method lies in the fact that in addition to compressing the chest it actively expands it, thus permitting more effective exchange of air. The two-phase cycle shown is repeated 12 times per minute, with the expansion and compression phases of equal duration, and the time of release a minimum.

(Continued on page 18)

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Service Records of Cast Iron Water and Gas Mains
Pacific Ocean
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• Black dots represent original cast iron mains in service
* Red stars represent cast iron mains in service 100 years or more

AMERICA PROVES IT! The above map shows cities having some or all of their *original* cast iron water or gas mains still in service. The red stars indicate 34 cities having cast iron water or gas mains in service that were laid a century or more ago.

SURVEYS PROVE IT! A recent study directed by 3 Water Works Associations shows that 96% of all cast iron water mains, 6-inch and over, *ever laid* in 25 representative cities, are still in service.

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Europe proves it! The oldest cast iron water mains in the world, by authenticated records, supply the town and parks of Versailles, France. They were installed in 1664 and are still functioning after 287 years of service. Other cities in France, Germany and the British Isles have cast iron mains in service that are over 100 years old.

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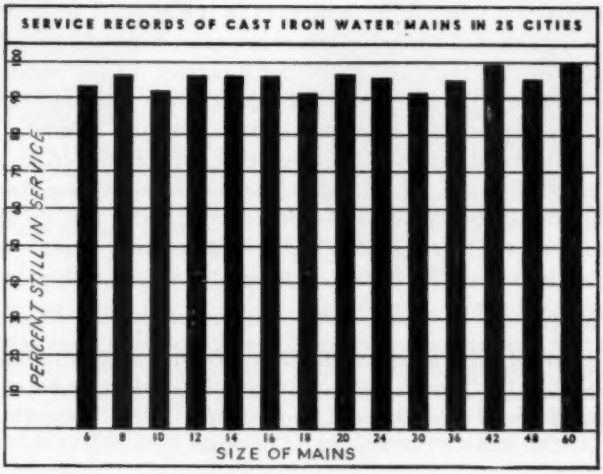
Surveys prove it! An exhaustive study, directed by a Joint Committee representing 3 Water Works Associations, shows that 96% of all cast iron water mains, 6-inch and over, *ever laid* in 25 representative cities, are still in service (see chart).

Yes, history proves beyond doubt that cast iron pipe has the stamina and the strength-factors that pipe must have to serve dependably under the paved streets of cities, towns and villages.



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SERVES FOR CENTURIES

The Reading Meter

Data Book for Civil Engineers. I. Design. II. Specifications and Costs. *Elwyn E. Seelye. John Wiley & Sons, Inc., New York (2nd ed., 1951) Vol. I—$10; Vol. II—$13*

These ponderous volumes represent an anthology of data, charts and tabulations compiled from numerous sources. As a work of assembling into two readily accessible volumes a digest of essential engineering information from sources that are not often all available to the designer, the books serve a real need. Perhaps their greatest value is that they furnish reference data to the specialist on matters that are outside his immediate field, but within the scope of specific projects on which he has to work

The greatest weakness of the books is their very breadth. With so many sources to be culled for data, it is perhaps inevitable that the compiler be unable to keep accurate track of all the changes and innovations that occur in his sources. In the chapters on water supply and treatment, for example, there are numerous references to outdated sources, although one of the stated reasons for the issuance of a second edition was to bring the books up to date. The drinking water standards, in particular, are taken partly from the 1946 and partly from the 1942 editions, with the result that the presence of hexavalent chromium in any amount is termed grounds for rejection of the water, although the 1946 *Standards* permits concentrations up to 0.05 ppm. Similarly, all references to AWWA's *Water Quality and Treatment* are taken from the 1941 edition, although the second edition has been in print now for well over a year.

Chemical Character of Surface Waters of South Carolina, 1945–50. *F. H. Pauszek. Bul. 16A, South Carolina Research, Planning and Development Board, Columbia, S.C. (1951) free [available from U.S. Geological Survey, Box 711, Raleigh, N.C.]*

Chemical analyses of selected sampling points on rivers and streams are given on daily, monthly, or periodic bases. In addition, daily water temperatures for the "daily" stations are given, and the maximum-to-minimum range of dissolved solids for the 5-yr period is charted.

(Continued on page 18)

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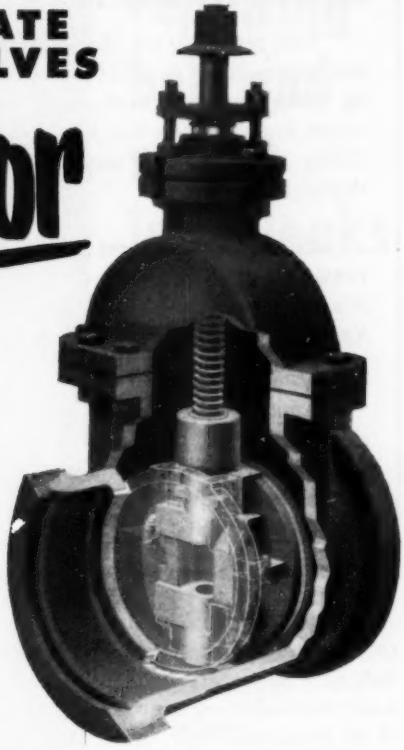

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The Reading Meter

(Continued from page 16)

Chemical Character of Surface Waters in Pennsylvania, 1946–49. *Pub. 23, Pennsylvania Dept. of Commerce, State Planning Board, Harrisburg, Pa. (1951) free*

This report on the chemical characteristics of Pennsylvania's surface waters is the result of a cooperative program of the U.S. Geological Survey and the Pennsylvania Dept. of Forests & Waters. It is a sequel to publication No. 17 of the State Planning Board, "Industrial Utility of Water in Pennsylvania—Chemical Character of Surface Water, 1944–46."

Chemical Character of Surface Waters of North Carolina, 1949–50. *F. H. Pauszek & K. F. Harris. Bul. 52, Vol. 6, Div. of Water Resources & Eng., Dept. of Conservation & Development, Raleigh, N.C. (1951) free [available from U.S. Geological Survey, Box 711, Raleigh, N.C.]*

Another example of Geological Survey cooperation with state agencies extends the available literature on the actual composition of regional surface waters. Daily, monthly and periodic data are given on chemical analysis, temperature, and discharge at various stations.

(Continued from page 12)

E. M. Converse, senior vice president of Dearborn Chemical Co., has retired after almost 50 years of service. He began his association with the firm as a laboratory worker in 1902, transferring to the Sales Dept. as a water treatment engineer six years later. By 1930 he had become manager of the Industrial Dept., and he was made vice president in 1949.

(Continued on page 76)

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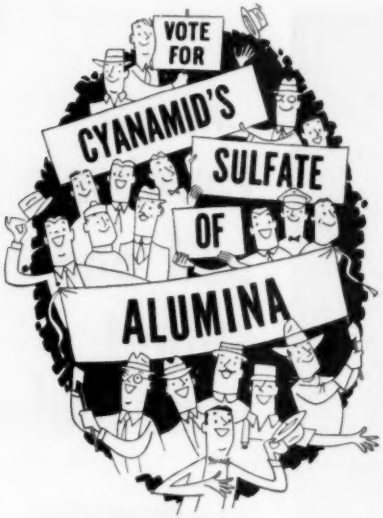

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To the Editor:

I noticed on page 2 of Percolation and Runoff of the December issue of the JOURNAL that there is a statement that San Francisco is riding high on the crest of an almost 2 to 1 support for fluoridation.

The Water Department was neutral in this issue and wants to remain neutral. The actual vote was: 114,125 "for" fluoridation and 88,377 "against." The *yes* votes were just a trifle under 30 per cent more than the *no* votes. This, in my opinion, is a long way from almost 2 to 1.

Even in Percolation and Runoff I think that the JOURNAL should present all of the facts fairly, and not let their likes and dislikes control the statements.

G. W. PRACY
Gen. Mgr. & Chief Engr.
Water Dept.
San Francisco 1, Calif.; Jan. 11, 1952

Mr. Pracy is of course correct. As our "facts" read 144,000 to 88,000, however, our rounding off was less off than the basic data from which we worked.—ED.

KC '52

To the Editor:

I was interested in "1951 Conference Statistics" appearing on p. 1028 of the December 1951 JOURNAL.

Being curious about distances traveled by members to the Miami meeting, I calculated that 461 people traveled

(*Continued on page 22*)

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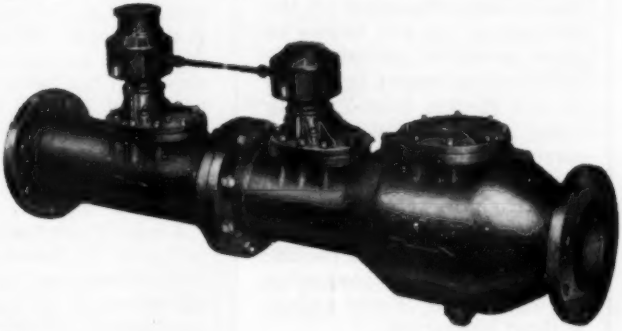

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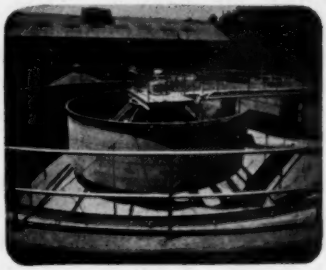

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(Continued from page 20)

less than 700 miles; 182 people traveled between 700 and 1,000 miles; 1,002 people traveled between 1,000 and 1,500 miles; and 175 people traveled more than 1,500 miles—all one way, of course. I also calculated that total mileage traveled by members to and from Miami was in excess of 4,000,000 miles, and this covers only those within continental U.S.

E. A. SIGWORTH
Chemist & Technician
Industrial Chemical Sales Div.
West Virginia Pulp & Paper Co.
New York 17, N.Y.; January 21, 1952

Which permits us to remind you that transportation reservation forms for the Kansas City Conference, May 4–9, have been mailed to you and should be completed and returned promptly.—ED.

Well?

To the Editor:

Remembering your "dowsing dithers" of times past, I am sure you will be interested in the fact that I have just found a client who really believes in the process. When a 400-ft rotary well which he had had drilled turned out dry, he had his ten acres thoroughly "witched." On the basis of the findings he put down a standard "California casing" well which hit two good water-bearing strata less than 300 ft east of the dry hole.

I was in grammar school when I first used the forked willow or peach stick to locate and the straight one to tell the depth to water. Although I have learned better since, I have a hard time convincing my farmer client.

LOREN E. BLAKELEY
Cons. Civ. & San. Engr.
Orange, Calif.; January 8, 1952

By the seismological techniques he described in the "Geophysics and Water" panel in the January JOURNAL *(p. 27), friend Blakeley ought to be able to explode anyone's ground water convictions. If not he, then who? Not we, perhaps you?*—ED.

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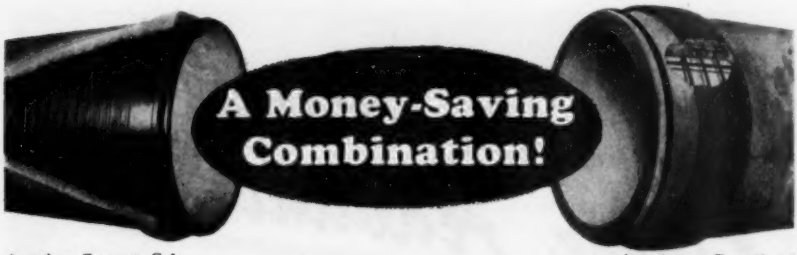

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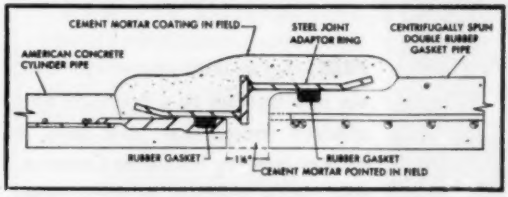
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Membership Changes

NEW MEMBERS

Applications received December 1 to December 31, 1951

Acosta Hechavarria, Roberto, Chief, Dpto. Servicio y Mantenimiento, Carrier Cubana, S.A., Lamparilla 9, Havana, Cuba (Jan. '52) *PR*

Amon, J. R., Chief Engr., Indianapolis General Hospital, 960 Locke St., Indianapolis, Ind. (Jan. '52) *MP*

Andrea, John Augustus, Engr., 2305 Glendale Ave., Durham, N.C. (Oct. '51) *MPR*

Arkansas State Board of Health, J. T. Herron, State Health Officer, Little Rock, Ark. (Corp. M. Jan. '52) *PR*

Askey, Sam F., *see* Marlow (Okla.)

Asplund, George, Gen. Contractor, Asplund Constr. Co., Box 1666, Enid, Okla. (Jan. '52)

Austin, John H., Teaching Asst., Massachusetts Inst. of Technology, Cambridge 39, Mass. (Jr. M. Jan. '52)

Barngrover, Lester, *see* Shawnee (Okla.) Munic. Water Dept.

Benigo, Joseph, Foreman, City Water Dept., City Hall, Garfield, N.J. (Jan. '52) *MPR*

Bigham, David H., Filter Plant Operator, Water Dept., Route 4, Lewisburg, Tenn. (Jan. '52)

Boulanger, Francis Achill, Machinist, Santa Fe R.R., 1245 Elmwood St., Evanston, Ill. (Jan. '52) *P*

Brewer, R. F., *see* Denison (Iowa) Munic. Utilities

Brince, Frank J., City Engr., City Hall, New Ulm, Minn. (Jan. '52) *M*

Burleson, Arthur, Water & Filtration Plant Supt., Baird, Tex. (Jan. '52) *P*

Burns, Alvin Daniel, City Engr., City Water & Gas Works, Richmond, Ky. (Jan. '52) *M*

Burns, Edward J., City Engr. & Supt. of Water, Board of Public Works, City Hall, Little Falls, N.Y. (Jan. '52) *M*

Ciner, James H., Jr., Hydr. Engr., U.S. Geological Survey, 301 Porbeck Bldg., Little Rock, Ark. (Jan. '52) *R*

Clausen, Ervin H., Mgr., Industrial Products Div., Johns-Manville Sales Corp., 116 New Montgomery St., San Francisco 5, Calif. (Jan. '52) *M*

Clawson, W. K., Partner, M. M. Dillon & Co., 365 Richmond St., London, Ont. (Jan. '52)

Cosper, Bert L., *see* Henryetta (Okla.)

Curington, H. W., Chief Engr., The Marvin Turner Engrs., Nalle Bldg. Annex, Austin 1, Tex. (Jan. '52)

Currie, George N. M., Sales Engr., Charles E. Napier Co., Ltd., 362 Oakwood Ave., Toronto 10, Ont. (Jan. '52)

de Castro Prado, Rocio, Hydr. Engr., Sociedade tecnica e Commercial Sitec S.A., Rua da Consolacao 820, Sao Paulo, Brazil (Jan. '52) *M*

DeLozier, Paul O., Chem. Engr. & Mgr., Treat-Rite Chem. Co., Inc., Nowata, Okla. (Jan. '52) *P*

Denison Munic. Utilities, R. F. Brewer, Supt., Denison, Iowa (Mun. Sv. Sub. Jan. '52) *MPR*

Doerfler, L. M., Gen. Mgr., Doerfler Constr., 2514 S. Agnew, Oklahoma City, Okla. (Jan. '52)

Dunbar, C. Kyle, *see* Mason-McCain, Inc.

Dutton, Lendon F., Supt., Dept. of Utilities, 359 Thames St., Groton, Conn. (Jan. '52)

Enta, Chinoree T., Jr. Water Chemist, S. Dist. Filtration Plant, 3300 E. Cheltenham Pl., Chicago 49, Ill. (Jan. '52)

Firth, William D., Asst. Operator, Flemington Water Co., Box 281, Flemington, N.J. (Jan. '52) *MP*

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(*Continued from page 30*)

Frey, Arthur E., Sales Engr., Tested Appliance Co., 2627 W. 19th St., Chicago 8, Ill. (Jan. '52) *P*

Frick, Arthur C., Chief Engr. of Power Plants, City Water Works, City Hall, Milwaukee, Wis. (Jan. '52)

Gilkey, Maurice M., Supt., Munic. Water Works, Waynetown, Ind. (Jan. '52) *M*

Glade, William P., Owner, Glade Constr. Co., 403 Century Bldg., Fort Worth, Tex. (Jan. '52)

Hamblin, Clifford W., Water Supt., Water Dept., Mason City, Iowa (Jan. '52) *M*

Henryetta, City of, Bert L. Cosper, Water Supt., City Hall, Henryetta, Okla. (Mun. Sv. Sub. Jan. '52) *MP*

Herron, J. T., *see* Arkansas State Board of Health

Hill, J. B., Sales Engr., American Cast Iron Pipe Co., 7429 Fontana Rd., Mission, Kan. (Jan. '52) *M*

Hutchinson, R. E., Supt., Water & Sewer Maint., High Point, N.C. (Jan. '52) *M*

Japanese Water Works & Sewerage Assn., Seiichiro Yasui, Pres., 23, 2-Chome, Moto-Machi, Bunkyo-Ku, Tokyo, Japan (Corp. M. Jan. '52)

Johnstone, W. F., Gen. Mgr. & Supt., Box 995, Riviera Beach, Fla. (Jan. '52) *M*

Jones, Jesse H., Field Engr., Industrial Chemicals Inc., 2215 S. Main St., South Bend, Ind. (Jan. '52) *P*

Kell, Waldo R., Asst. Sales Mgr., Centriline Corp., 1004 Baltimore, Kansas City, Mo. (Jan. '52)

King, Alan G., Salesman, Mathieson Chem. Corp., 220 N. 4th St., St. Louis, Mo. (Jan. '52)

Kinser, Richard E., Chemist, State Board of Health, 1330 W. Michigan, Indianapolis, Ind. (Jan. '52) *P*

Larose, Gerard, Professional Engr., Public Works, 2539 Elsdale St., Montreal, Que. (Jan. '52)

Lewis, J. Dee, Salesman, The Hutchinson Foundry & Steel Co., D & Washington, Hutchinson, Kan. (Jan. '52)

Lewis, Melvin Gordon, City Engr., Weiser, Idaho (Jan. '52) *MP*

Likely, Robert G., Sales Mgr., Jos. A. Likely, Ltd., Box 655, St. John, N.B. (Jan. '52)

(*Continued on page 34*)

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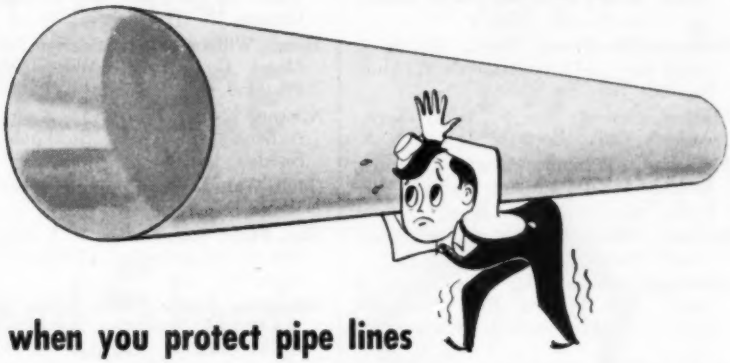

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Manson-McCain, Inc., C. Kyle Dunbar Assoc., 8200 Florida St., Baton Rouge, La. (Corp. M. Jan. '52) *P*

Margaretville Water Dept., Walter J. Odell, Supt., Margaretville, N.Y. (Mun. Sv. Sub. Jan. '52) *M*

Marlow, City of, Sam F. Askey, Supt., Marlow, Okla. (Corp. M. Jan. '52) *R*

Measures, William Henry, Operator, Wadley Field Pumping Station, Midland, Tex. (Jan. '52) *PR*

Meyers, Herbert W., *see* Olivehurst (Calif.) Public Utility Dist.

Middaugh, Ernest D., Cons. Engr. & Mgr., The Francis Eng. Co., 509 Empire Bldg., Rockford, Ill. (Jan. '52) *M*

Milano, Leonard, Consultant, Commonwealth Services Inc., 20 Pine St., New York 5, N.Y. (Jan. '52) *M*

Miller, Joseph H., Mgr., Industrial Dept., Antony Gibbs & Co., Ltd., 230 Bay St., Toronto, Ont. (Jan. '52)

Moloney, John Irwin Thomas, Student, Univ. of Illinois, 910 College St., Urbana, Ill. (Jr. M. Jan. '52) *P*

Moore, William Edgar, Salesman, Neptune Meter Co., 1238 N.W. Glisan St., Portland, Ore, (Jan. '52) *M*

Nilsson, Nils, Pres., Apparatkemiska Aktiebolaget AKA, Stockholm 15, Sweden (Jan. '52)

Odell, Walter J., *see* Margaretville (N.Y.) Water Dept.

Oldt, Floyd Stix, Owner, F. S. Oldt Co., 403 S. Haskell Ave., Dallas 1, Tex. (Jan. '52) *PR*

Olivehurst Public Utility Dist., Herbert W. Meyers, Pres., Box 783, Olivehurst, Calif. (Corp. M. Jan. '52) *M*

Patton, Richard Earl, Constr. Engr., McNary Dam Contractors, Box 132, Umatilla, Ore. (Jan. '52) *R*

Persico, Peter, Pres., Persico Bros., Inc., 48 Broad St., Amsterdam, N.Y. (Jan. '52) *M*

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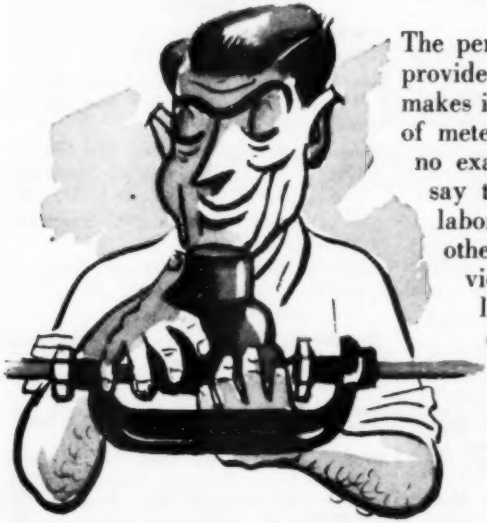

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(*Continued from page 34*)

Peterson, Claude, *see* Ruidoso (N.M.) Water Dept.

Ratliff, John W., Project Mgr., Glade Constr. Co., 403 Century Bldg., Fort Worth, Tex. (Jan. '52)

Rorschach, Richard Gordon, Vice-Pres., H. E. Rorschach & Sons, 432 Kennedy Bldg., Tulsa, Okla. (Jr. M. Jan. '52) *R*

Ruidoso Water Dept., Claude Peterson, Maint. Supt., Ruidoso, N.M. (Mun. Sv. Sub. Jan. '52) *M*

Salcines, Jose Lecticio, Cons. Engr., 502—23rd St., Vedado, Havana, Cuba (Jan. '52) *R*

Sawyer, Alfred W., Partner, Hazen & Sawyer, 110 E. 42nd St., New York, N.Y. (Jan. '52) *MPR*

Shawnee Munic. Water Dept., Lester Barngrover, Supt., Shawnee, Okla. (Corp. M. Jan. '52)

Smith, Stanley Monroe, Dist. Engr., Div. of San., State Board of Health, City Hall, Salina, Kan. (Jan. '52) *P*

Stiff, Churchill K., Dist. Mgr., Factory Mutual Eng. Div., 333 Montgomery St., San Francisco 4, Calif. (Jan. '52) *M*

Stoner, David Scott, Chief, Branch of Irrigation Operations, U.S. Bureau of Reclamation, Region 2, Sacramento, Calif. (Jan. '52) *MR*

Sugiura, Ryuji, Pres. & Director, Suido Kiko K. K., No. 7, 3-chome, Gofukubashi, Nihonbashi, Chuo-ku, Tokyo, Japan (Jan. '52) *P*

Tadlock, J. H., Office Mgr., Glade Constr. Co., 403 Century Bldg., Fort Worth, Tex. (Jan. '52)

Wade, Robert W., Engr.-in-Charge, Munic. Com., Herkimer, N.Y. (Jan. '52)

Watt, David, Engr. & Mgr., Public Utilities Com., Cochrane, Ont. (Jan. '52)

Wege, Ervin Carl, Section Engr., Water Constr. Div., City Water Works, City Hall, Milwaukee, Wis. (Jan. '52) *M*

Yasui, Seiichiro, *see* Japanese Water Works & Sewerage Assn.

Zimmerman, Harold Smith, Bacteriologist, City Water Dept., 20 E. Salem Ave., Roanoke, Va. (Jan. '52) *P*

REINSTATEMENT

Barrett, J. S., *see* Virginia, Commonwealth of

Case, Ray, *see* Greeley (Colo.)

Greeley, City of, Ray Case, City Mgr., Greeley, Colo. (Corp. M. Apr. '26) *MP*

Kupper, Charles J., Cons. Engr., 15 Shelton Rd., New Market, N.J. (June '29)

Lewis, Harley A., Supt., Mulberry Water Co., Mulberry, Ark. (Oct. '43)

Perazzo, Roberto J., Civ. Engr., Administracion Nacional del Agua, Potosi 4052, Buenos Aires, Argentina (Jan. '45)

Sene, Otacilio P., Escola Politecnica, Praca Cel. Fernando Prestes 74, Sao Paulo, Brazil (July '48)

Virginia, Commonwealth of, Div. of the Budget, Section of Institutional Eng., J. S. Barret, Civ. Engr., 117 Ballard St., Richmond 19, Va. (Corp. M. Oct. '48) *MPR*

LOSSES

Deaths

Bennett, James H., Supt. of Public Works, San Clemente, Calif. (Oct. '41) *MPR*

Bray, Wesley R., Scranton Spring Brook Service Co., 135 Jefferson Ave., Scranton, Pa. (Jan. '48)

Campbell, John T., Partner, The Chester Engrs., 210 E. Parkway at Sandusky, N.S., Pittsburgh 12, Pa. (Oct. '31) *R*

Chase, Horace H., Box 198, Sandwich, Mass. (May '24)

Coles, L. Dudley, Chief Engr., Dept. of Public Works, City Hall, Newark 2, N.J. (July '43) *MPR*

Daugherty, Frank, Pres., Scofield Eng. Co., 1324 Commercial Trust Bldg., Philadelphia 2, Pa. (Mar. '31) *MPR*

Dougherty, Ben R., Supt., Water & Gas Works, Richmond, Ky. (Apr. '24)

Dugger, Eugene F., Gen. Mgr., Water Works Com., Newport News, Va. (May '24) *Fuller Award '43. Director '34–'37, '38–'39. M*

Gayton, Loran D., Asst. City Engr., Dept. of Public Works, 402 City Hall, Chicago 2, Ill. (Oct. '24)

(*Continued on page 38*)

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Harrison, Wayne K., Water Works Engr., Public Service Dept., 164 W. Magnolia Blvd., Burbank, Calif. (July '48) *MR*

Joos, C. E., Vice-Pres. & Gen. Sales Mgr., Water Conditioning Div., Cochrane Corp., 17th St., & Allegheny Ave., Philadelphia 32, Pa. (Apr. '39)

Lanigan, Roy A., Foreman, Water Dept., Box 191, Burlingame, Calif. (Apr. '47) *MR*

McWilliams, John S., Pres., Roaring Creek Water Co., 204 E. Sunbury St., Shamokin, Pa. (Apr. '43) *M*

Miller, Fabian S., City Engr., City Hall, Palo Alto, Calif. (Jan. '46)

Sleeper, Benjamin A., Civ. Engr. & Surveyor, 501 Cooper St., Camden, N.J. (Dec. '30)

Toman, R. S., Dist. Mgr., Chemical Equipment Co., 1217 Engineering Bldg., Chicago 6, Ill. (Jan. '40) *P*

Totman, W. A., Asst. City Mgr., 552 E. "E" St., Ontario, Calif. (Oct. '50)

Townsend, Albert Mac, Supt. of Distr., Water Dept., Beaumont, Tex. (Jan. '51) *MPR*

Resignations

Adams, Howard Leslie, Miami, Fla.

Armstrong, Donald, Burlington, N. J.

Beckman, Wallace J., Brooklyn, N. Y.

Binyon, Hugh A., Petersburg, Fla.

Boggs, Harry, Indianapolis, Ind.

Brand, Charles W., Miami, Fla.

Breeding, C. S., Northfork, W.Va.

Brown, Walter M., Long Beach, Calif.

Cain, Tom J., San Jacinto, Calif.

Chaney, Howard E., Baltimore, Md.

Clift, Mortimer A., Indianapolis, Ind.

Cloroben Corp., The, Jersey City, N.J.

Colston, Robert, Chicago, Ill.

Creamer, Gertrude M. (Miss), Tuckahoe, N.Y.

Deas, R. R., Jr., Anniston, Ala.

Drew, E. C., Santa Cruz, Calif.

Edwards, William J., Cumberland, Md.

Ellsworth, Robert Bruce, Indianapolis, Ind.

Gantt, Joseph I., Lynchburg, Va.

Gearhart, John C., Portland, Ore.

Gustafson, J. P., Lafayette, Calif.

Hale, Thomas Shaw, New York, N.Y.

Hammermill Paper Co., Erie, Pa.

Harvey, Louis Robinson, Spokane, Wash.

Hottinger, S. E., Jr., New Orleans, La.

Kilby, H. S., Tulsa, Okla.

King, Leslie R., Wichita, Kan.

Kingsbury, Harold N., Madison, Wis.

Laramy, Jack B., Chicago, Ill.

Lasley, James B., Lancaster, S.C.

Lawrence, John A., Ottawa, Kan.

Mason City Water Dept., Mason City, Iowa.

McMains, Norman L., Terre Haute, Ind.

Missouri Power & Light Co., Jefferson City, Mo.

Morenci Water & Elec. Co., The, Morenci, Ariz.

Nier, Edward F., Rochester, N.Y.

Nutting, H. C., Cincinnati, Ohio

(Continued on page 40)

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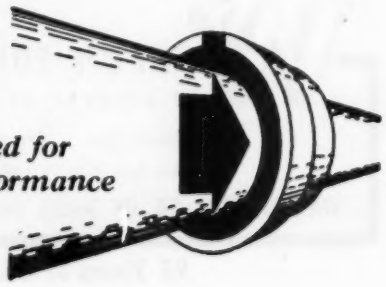

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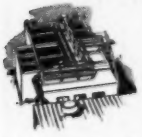

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(Continued from page 38)

Paddock Eng. Co. of Texas, Dallas, Tex.
Payrow, Harry Gordon, Bethlehem, Pa.
Perkins, Frank P., Omaha, Neb.
Phoenix, Edward A., New York, N.Y.
Pittman, Claud, McCaysville, Ga.
Pyatt, Edward M., Jr., Noblesville, Ind.
Sax, Arthur C., New York, N.Y.
Sherman, Arthur L., Washington, D.C.
Shull, Ivan F., Lawrence, Kan.
Sloan, Walter John, Wilmington, Del.
Small, Leon, Montgomery County, Md.
Trousdale, E. A., Mt. Vernon, Ind.
Wagner, Fred, Palo Alto, Calif.
Zorn, Ray H., Oak Harbor, Ohio

CHANGES IN ADDRESS

Changes received between December 5, 1951 and January 5, 1952

Barnhill, Kenneth G., 1009 Jackson Rd., Park Heights, Covington, Ky. (July '39)

Black, Ralph J., Asst. San. Engr., State Dept. of Health, 1425 Navellier St., El Cerrito 6, Calif. (Apr. '51)

Byron, John C., Sr. San. Engr., State Dept. of Public Works, 19 Euclid Ave., Elsmere, N.Y. (Jan. '49) *P*

Crete, City of, C. R. Weaver, Comr., Light, Water & Sewer Depts., 243 E. 13th St., Crete, Neb. (Corp. M. July '46)

Dunmire, E. H., Cons. Engr., City Hall, Rapid City, S.D. (Apr. '40) *P*

Firth, William J., Beafort, S.C. (Jan. '43) *MP*

Gray, Arthur E., Brooklake Rd., Florham Park, N.J. (Apr. '47)

Hicks, W. F., Cons. Engr., 34 Clarksville St., Paris, Tex. (Jan. '35) *M*

Holly Hill, City of, City Council, Holly Hill, Fla. (Oct. '49) *MP*

Hopkins, Edwin W., R.D. 1, Nassau, Rensselaer County, N.Y. (Aug. '25)

Johnson, Francis M., Office of Surgeon, Headquarters, Technical Training Air Force, Gulfport, Miss. (Oct. '37) *PR*

Kenmir, Russell Collingswood, 704 Story Pl., Alhambra, Calif. (Oct. '50)

Kershaw, Neil F., 117 Upnor Rd. Baltimore, Md. (Jan. '37) *P*

MacPherson, William, Gen. Delivery, Aiken, S.C. (July '49) *MP*

McCormick, Robert E., Cons. Engr., Apt. 606, 9027 W. Shorewood Dr., Mercer Island, Wash. (Apr. '49)

McHugh, Arthur C., 76 Burhans Pl., Delmar, N.Y. (Jan. '44)

McKay, W. G., Asst. Engr., Underwood & McLellan, 502 Grain Bldg., Saskatoon, Sask. (Jan. '42)

Moore, Theodore L., Gibbs & Hill, Inc., 127 Minnehaha Blvd., Lake Hiawatha, N.J. (Apr. '47) *MPR*

Mortenson, F. C., 801 S. 4th, Leavenworth, Kan. (Apr. '40) *P*

Murray, Walter, Engr., 4685 Mariette Ave., Montreal, Que. (Jan. '48)

Rhodes, Fred, Cons. Engr., 434 Land Title Bldg., San Diego, Calif. (Oct. '34) *M*

Ritchie, Richard J., Cons. Engr., 161 Castle Ridge Rd., Manhasset, N.Y. (Jan. '43) *P*

Santa Barbara, City of, E. M. Thompson, Supt., Water Works Dept., City Hall, Santa Barbara, Calif. (Corp. M. Oct. '37) *MPR*

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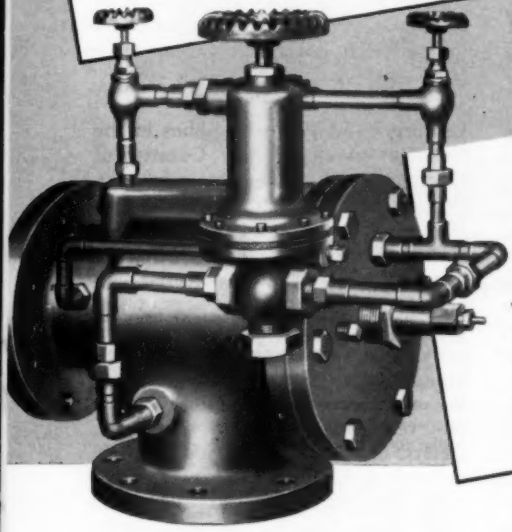

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Key: In the reference to the publication in which the abstracted article appears, **39**:473 (May '47) indicates volume 39, page 473, issue dated May 1947. If the publication is paged by the issue, **39**:5:1 (May '47) indicates volume 39, number 5, page 1, issue dated May 1947. Abbreviations following an abstract indicate that it was taken, by permission, from one of the following periodicals: *B.H.—Bulletin of Hygiene (Great Britain); C.A.—Chemical Abstracts; Corr.—Corrosion; I.M.—Institute of Metals (Great Britain); P.H.E.A.—Public Health Engineering Abstracts; S.I.W.—Sewage and Industrial Wastes; W.P.A.—Water Pollution Abstracts (Great Britain).*

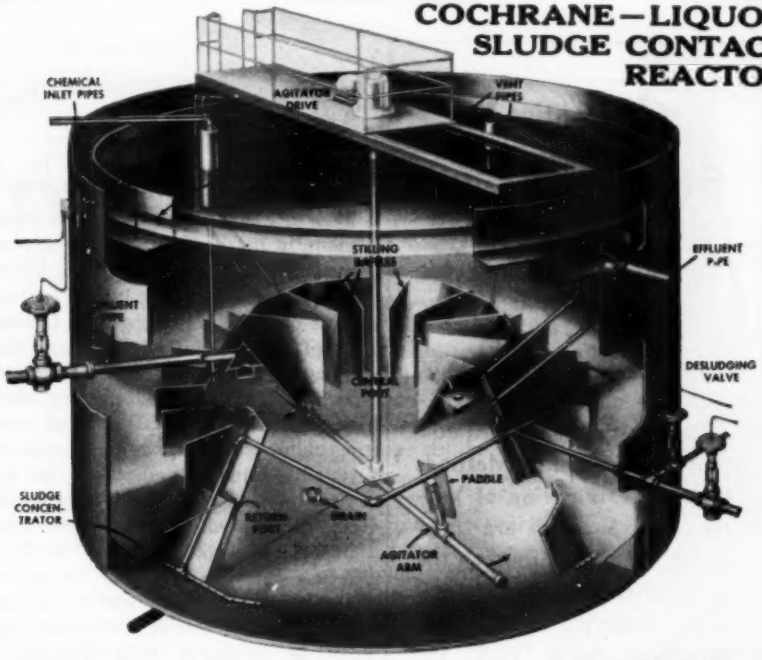
SOURCES OF SUPPLY

The Problem of Gravel in Highland Watercourses. C. L. CLAYTON. J. Inst. Wtr. Engrs. (Br.), **5**:400 ('51). Constant weathering of mountain rock faces produces boulders which disintegrate and eventually reach watercourses in form of gravel, filling rivers and reducing carrying capac. Gravel removal immense task. Continuous maint. of rivers by cleansing is financially difficult. Government grants available for improvement work. Answer is compromise. Maint. on rivers can be restricted to selected points supplemented by system of gravel traps in hill feeders. Traps generally should be located at point where fell land joins agricultural land at sudden lessening of gradient, with resultant tendency to deposit gravel. Crudest form of trap consists of obstruction or series of obstructions made by lodging large boulders across stream. There are traps constructed wholly of concrete in form of miniature dams. Control method simple. Learned by experience. Tendency is to clean traps after each filling. If signs of scour appear, trap should not be cleaned until regimen required in river has been restored. If silting is evident, and cleaning is not sufficient to preserve regimen, additional trap needed. Cleaning time often governed by availability of men and plant and demands of other work. Gravel traps used in conjunction with cleaning are soln. to problem of siltation in highland watercourses. Chief advantages are: [1] some control of movement of gravel, [2] control of points of extraction of gravel, [3] easy access for cleaning, [4] some choice of cleaning time, [5] use of gravel for other purposes, [6] gradual restoration of waste land by tipping, [7] nonutilization of good land, such as might become overspread during normal river cleaning.—*H. E. Babbitt*

Underground Water Supplies in the Coalfield Area of the County of Durham. W. HOPKINS. J. Inst. Wtr. Engrs. (Br.), **5**:300 ('51). Water from flooded underground workings of derilict collieries of Durham coalfield may form potential supply if qual. satisfactory after treatment. Coal measures of Durham comprise usual alternating series of shales, sandstones, fireclays, and coals. Water engr. interested in sandstones as they often contain feeders of varying quants. of water. Small feeders yield as much as 125 gpm (Imp.). If sandstone well fissured, feeders may yield 1,000 gpm (Imp.). In some areas adjacent to old valley, particularly near Durham, water also finds its way through well jointed sandstone which outcrops at surface or is concealed by thin covering of dirt. Statistics on quants. of water available are recorded in Report of Ministry of Fuel and Power Regional Survey and show flows from dists. north and south of Butterknowle Fault from 400 to 2,000 gpm (Imp.). Other colliery waters not so favorable for use as public water supply are not being exploited at present because of undesirable na-

(Continued on page 44)

COCHRANE—LIQUON SLUDGE CONTACT REACTOR



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6. Slurry spreads out across full area of tank above crest of baffles, water rising slowly to separate from sludge.
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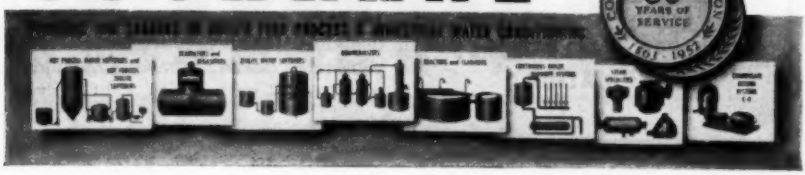

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(*Continued from page 42*)

ture of chem. constituents.—*H. E. Babbitt*

Moorland Gripping. W. H. E. RIVETT. J. Inst. Wtr. Engrs. (Br.), 5:497 ('51). Peat bogs occur in regions in north of England where annual rainfall varies from 50 to 150 in. Many bogs are built up of mosses, most common being bogmoss (*Sphagnum*), which can absorb and retain many times its own weight of water. To keep sheep on fell country where these conditions prevail, type of drainage known as sheep gripping was initiated. Usually undertaken on two types of land: deep beds of peat resting on impermeable rock, and semi-impermeable soils with few inches of peat covering. Trench is cut approx. 18 in. deep, 12 in. wide at top, and 3 in. wide at bottom. Drainage cannot be compared with drainage of permeable soils where, through lowering of water table, temporary storage capac. created to take water from sudden storms. Design of drainage system for moorland gripping is similar to tile or pipe drainage scheme in which trenches have been left open. After time, unless maint. is thorough, grips become blocked and *Sphagnum* mosses grow again.—*H. E. Babbitt*

ACCOUNTING AND FINANCING

Financial Considerations Applicable to Waterworks Management. L. WESTON. J. Inst. Wtr. Engrs. (Br.), 5:499 ('51). Local authorities finance undertakings by borrowing. Loans amortized over fixed periods. Amortization periods for: land, 60–80 yr.; bldgs., 30–60 yr.; mchy. and plant, 15–25 yr.; mains, 30–40 yr. In impounding schemes, initial capital expenditure heavier than in pumping schemes. Charges for debt service

(*Continued on page 46*)

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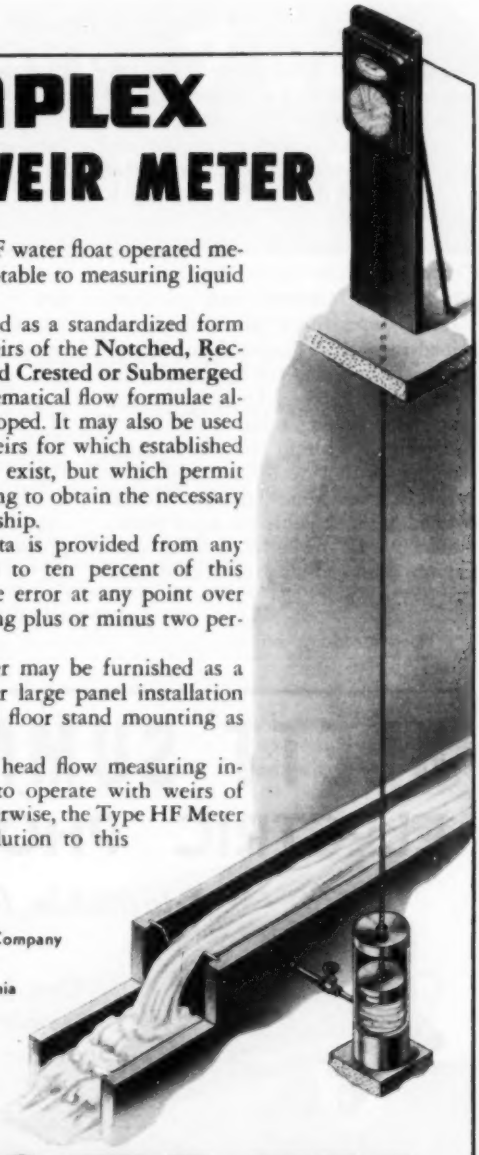

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(Continued from page 44)

largest item of expenditure. For rating and income tax purposes, such charges not allowed as working expense. This liability to rating and income tax is sidestepped by resorting to "deficiency rate." Principle introduced to safeguard against accumulated loss in accts. of local authority. Companies raise capital by shares on which max. dividend rate is fixed. Capital expenditure permanently retained in accts. Replacement of capital assets provided for by reserve and contingency funds. Local authorities may levy public water rate on all properties within statutory area, whether or not water is supplied to premises; companies cannot. Rental formed basis of value for most hereditaments. In owner-occupiers, comparison with similar properties enabled fixing of value. Rental method lacks uniformity, which, in rateable values, has repercussions in development of rural supplies. Increases in postwar bldg. costs caused serious anomalies in rental values between houses subject to rent restriction and postwar houses. Conservative est. of avg. modern residence is 100 gpd. Taking house of £20 rateable value with water rate 9% on net annual value, annual income shows return of 1/– per 1,000 gal, but few undertakings can cover expenses at this rate. In assessment of water undertakings, structural method assumes reasonable return on capital cost, usually 4% on land and 5% on bldgs. Accts. method assumes hypothetical tenant of water-works property will determine rent he is willing to pay on probable profits. In-

(Continued on page 48)

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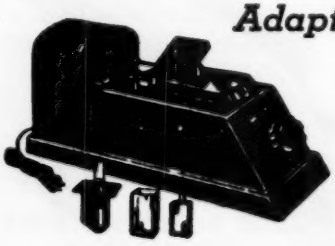

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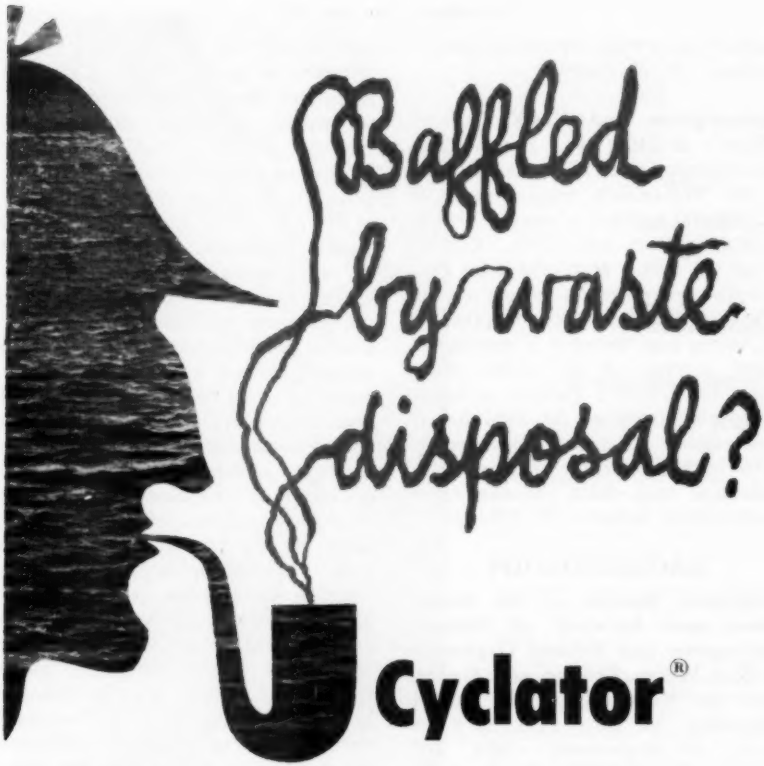
(Continued from page 46)

come tax assessed on profits for previous yr. No capital charges allowed against profits. Only charges incurred in earning revenue allowed. Loss for one yr. may be set off against profits in subsequent years. After detg. net receipts, deduction is made for tenant's share. Balance divisible between rates and landlord, technically "net annual value plus rates." Distr. mains without reservoirs, pumping stations, and trunk mains would be useless, but, in rating latter, are classed as indirectly productive—they do not directly produce revenue. Acctg. method first applied when commercial principles were in operation in running public utilities. Application of structural method would give better std. Undertaking owned by local authority can subsidize consumers by denying reasonable rate contribution to neighboring parishes. Done merely by ensuring that receipts barely cover working expenses and are insufficient to pay loan charges. Sinking fund allowance for replacements which appears in rating assessment omitted from income tax assessment, but allowance made is calculated in different manner. Replacement of mchy. and plant allowed as revenue expense, as distinct from capital expense. If replacement more expensive than original, only lesser amt. could be claimed. Rule for allowance on basis of renewals varied in '42. Following allowances based on written-down values adopted: mains, 3%; meters, 7½%; diesel engines, 10%; other plant, 5%. Initial allowances introduced to encourage industry to invest profits in modern mchy. Allowances operate as relief of taxation on profits so invested. In deciding on new works, managements should remember resultant increase in ratable value of indirectly productive portions and wherever possible site

(Continued on page 50)



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(Continued from page 48)

works in area with low rate in pounds sterling.—*H. E. Babbitt.*

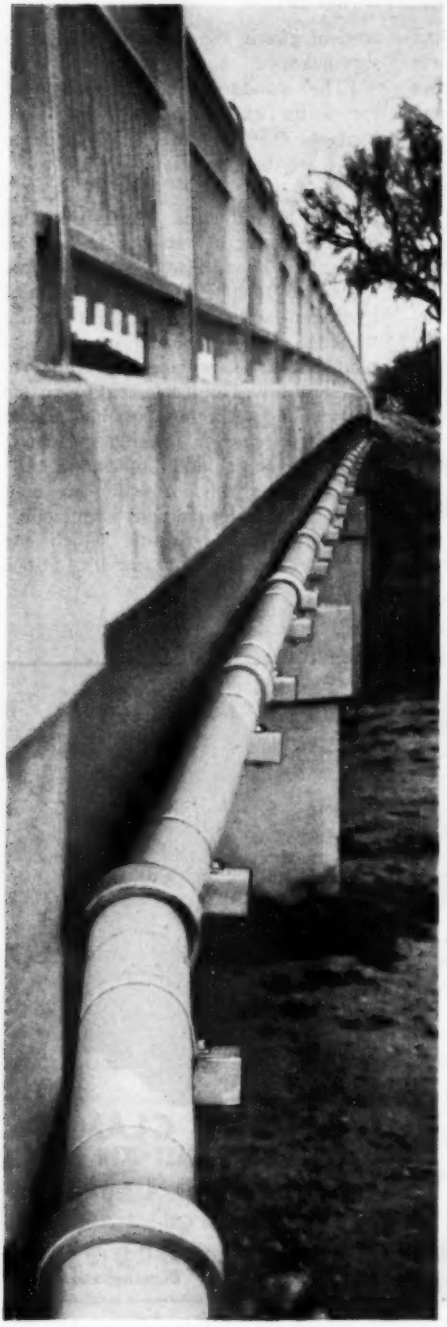
Consumption and Costs. Water (Neth.), **35**:240 ('51). Expenditures for consumption of all kinds has risen in the Netherlands from an avg. of 922,000,000 guilders a mo. in 1948 to 1,136,000,000 in July, 1951. Considering the rising costs, the total consumption increased 2%, which is actually a reduction in consumption of 4% when pop. increase is considered. Total income of all water works amts. to 4,750,000 guilders a month or approx. 0.4% of the total for all consumption. General increase of 25% in water works income would constitute only 0.1% of the entire consumption budget.—*W. Rudolfs.*

BACTERIOLOGY

Literature Review on the Occurrence and Survival of Enteric, Pathogenic and Related Organisms in Soil, Water, Sewage, and Sludges and on Vegetation. II, Animal Parasites. W. Rudolfs, L. L. Falk, & R. A. Ragotzkie. Sew. Ind. Wastes, 22:417 ('50). First section of survey concerned with pathogenic parasite, *E. histolytica,* which may be transmitted by contamd. water, foodstuffs grown on contamd. soil or handled by carriers, and by flies. Goes into detail on sanitation of vegetables grown in contamd. soils. High incidence of amebic dysentery in a refugee camp in Palestine was substantially reduced by immersion of all fruits and vegetables in a 200 ppm hypochlorite bath, followed by rinsing in clean water. Goes into details of conflicting work done to study the thermal death point and survival of *E. histolytica* cysts. Early studies indicated at least 100 ppm chlorine would be needed to kill *E. histolytica* cysts but more recent work shows 2–15 ppm may be effective, depending upon type of chlorine compd. used. Free chlorine is most lethal. Cysticidal properties depend upon temp. concn., pH, contact time, org. matter present, and cyst density. Four quarternary ammonium compds. found to be eff. cysticides at 30-ppm concn. for 10 min or 10 ppm for 2 hr. In water and sewage treatment, sand filters found to retain cysts. Second section is similar review of literature covering the helminth parasites, such as tape worms, *Hymenolepis nana* and *Taenia saginata*; round worms, *Ascaris lumbricoides* and *Trichuris trichuria*; and hook worms, *Necator americanus* and *Ancylostoma duodenale.* Most larvae and eggs of these species can live in contamd. soil long enough to be factor in the transmission of intestinal diseases by means of vegetables and fruits. Helminth eggs and larvae could be found in sewage sludges after 62 days' drying. Indiscriminate use of such sludges for fertilizer might spread eggs of these parasites. These eggs also found to survive primary settling, trickling filter, and activated sludge treatment. Slow sand filtration eff. in removed eggs. Five-mo. aeration in activated sludge process does not remove eggs. Anaerobic sludge diversion for 6 mo still shows 30–46% of eggs to be normal in appearance. Recommendations given for the protection of sewage farm vegetables.—*P.H.E.A.*

Relationship of Coliform Bacteria to Gas Production in Media Containing Lactose. C. W. Chambers. Pub. Health Repts., **65**:619 (May 12, '50). In routine water examns. coliform bacteria have to compete in lactose broth tubes with other bacteria, which usually outnumber them by approx. 100:1, and, although growing, they may not attain the density necessary for the production of gas. Object of present work was to obtain infor-

(Continued on page 52)



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(Continued from page 50)

mation on this density. More than 1,000 tests were made with 32 coliform strains isolated from faeces. Tubes of the fluid media observed at intervals during incubation at 37 C and viable counts made when gas was noted. Results did not vary materially with differences in density of original inoculum, with the use of single and double strength lactose broth or with 10-ml and 17-ml vols of the medium. In many tests in lactose broth, the min. density of coliform bacteria with which gas production was first observed was 40,000,000 per ml. Mean and median values were approx. 170,000,000 per ml. Densities were approx. 40% less than required when 2% BGB was used. Results indicate negative routine test does not mean coliform bacilli are absent. Production of even a small amt. of gas in the presumptive test is significant.

[The standard lactose broth used for water examination in the U.S. contains 0.5% lactose, 0.5% peptone and 0.3% beef extract.]—*B.H.*

Some Malodorous Activities of Sulfate-Reducing Bacteria. K. R. BUTLIN. Proc. Soc. Applied Bact., 1949, p. 39 ('49). Active evolution of hydrogen sulfide by sulfate-reducing bacteria was often occurring in stagnant pools. Lowering pH value to less than 5 with sulfuric acid overcame the trouble. Another possible control method is removal of sulfide by chem. methods, such as addn. of zinc acetate. Where large vols. of water are concerned, possible method is introduction of micro-organisms which use hydrogen sulfide for growth. Such

(Continued on page 54)

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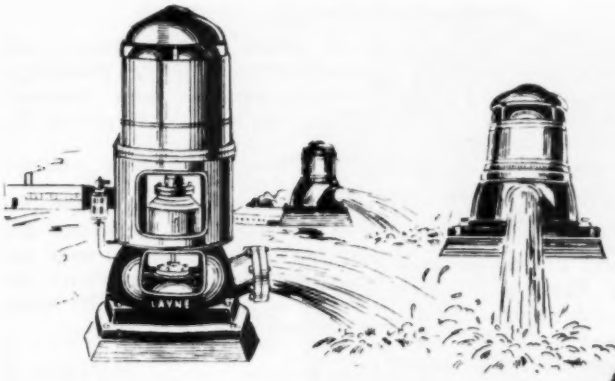

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(*Continued from page 52*)

organisms include *Thiobacillus denitrificans*, which uses nitrates to oxidize sulfide to free sulfur, and also photosynthetic purple and green sulfur bacteria which for satisfactory development need hydrogen sulfide, nearly anaerobic conditions, and sunlight.—*W.P.A.*

Characteristics and Culture of the Sulfate-Reducing Bacteria. Tech. l'Eau (Belg.), 3:7:5 (1949). Acct. given of the sulfate-reducing bacteria, their distr. and importance, their characteristics, and method of culture. By use of selective agents, certain of these can be isolated and grown in pure culture. In culture media used, sole source of sulfur should be sulfates, as in media containing org. sulfur compds. such as cystine, various microorganisms capable of forming sulfides.—*W.P.A.*

HYDROLOGY, CONSERVATION, AND IRRIGATION

Aspects of the Design Construction and Control of Water Supplies. W. K. Lewis. J. Inst. Wtr. Engrs. (Br.), 5:269 ('51). For rainfall and river-flow detns. throughout the British Isles, rainfall stations are available from which long-term records can be obtained. Stream or river gaging is most reliable method of detg. actual runoff. Commonest formula for detg. available yield of watershed is modified Hawksley formula:

$$Q_a = 62.15A(\tfrac{4}{5}R_{3d} - E),$$

where Q is available yield, in gpd (Imp.); A is watershed, in acres; $\frac{4}{5}R_{3d}$ is avg. rainfall, in in., for 3 consecutive driest years; and E is loss due to evapn., vegetable absorption, and percolation, and has usually been assessed to be from 14 to 16 in. of annual rainfall. Detn. of optimum reservoir capac. depends on cost and economics of return available from proposed scheme, and topography and geological features of site. Hawksleys reservoir formula states reservoir capac. giving constant delivery at Y_{3d} should have $\dfrac{1{,}000}{\sqrt{X_{3d}}}$ day's storage, where X_m is mean annual rainfall, X_{3d} is rainfall for three consecutive dry years and equals $\frac{5}{6}X_m$, and mean annual runoff for three consecutive dry years, Y_{3d}, is $(X_{3d} - 15)$ in. Rofe's rule became:

$$\text{reservoir capac.} = \frac{500}{\sqrt[3]{Y_{3d}}} \text{ day's storage}$$

with:

$$Y_{3d} = (\tfrac{4}{5}X_m - 14) \text{ in.}$$

Parker's third rule gave:

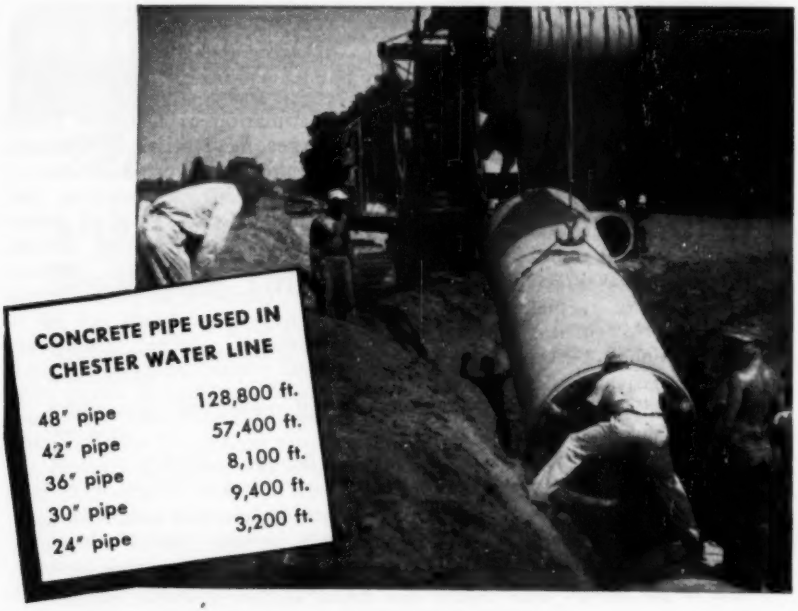
$$\text{capac.} = 1.7\text{–}1.8\,Y_{3d}^{0.67} \text{ in.}$$

In one of simplest forms, intake consists of chamber constructed at side of stream. Alternative form consists of low weir across stream against which intake screen is set at 45-deg angle to invert so that effect is modification of leaping weir. In design of intake gagings of flow are necessary to determine min. flow rate, max. flow rate, and monthly and yearly flow variations. In past, compensation has varied from $\frac{1}{4}Q$ to $\frac{1}{8}Q$, and often appears to have little real basis other than of some vague form of undefinable water rights. Compensation is provision to give some measure of balance of stream flow so that loss of high flows is compensated by elimn. of low flows. In computing compensation runoff, and not rainfall, forms only correct approach and proportion based on relationship (compensation): (Supply abstracted) = (1) : (n) is more logical. Following equation, deduced by author, is:

$$Fl = 0.175Y_{3d} + 2.5 \text{ in. per annum}$$

where Fl is generous low flow. Different aspects of importance is incidence and severity of floods. In gen-

(*Continued on page 56*)



Chester, Pa. Boosts Water Supply with 39-Mile Line of *CONCRETE PIPE*

To obtain adequate water for increased needs the Chester, Pa. Municipal Authority built a 39-mile concrete pipe line from a dam on Octorara Creek. Pipe sizes and quantities used are shown in the box. The engineers were Albright & Friel, Inc. of Philadelphia. The general contractor was the Berlanti Construction Company, Inc. of Harrison, N.Y.

Whether the water line you plan is long or short concrete pipe offers the rugged strength, long life and economy so necessary for satisfactory service. Tuberculation never occurs to impair hydraulic efficiency. Its tight joints and uniformly dense structure prevent leakage and infiltration.

Concrete pipe is clean and *stays* clean, thus minimizing taste, odor and dirty water difficulties. It meets all operating requirements, gives long years of ***low-annual-cost*** service.

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(Continued from page 54)

eral, engr. has to make reasonable provision during constr. for normal flows with margin for occasional floods and leave remainder to contractual risk. In design of pipelines, it is customary to use one of the well known formulas. Practice fundamentally wrong, although often of no great importance to final result. Error due to using horizontal projection of pipeline instead of actual developed length. Adverse criticism of performance of continuous-bucket excavators on pipeline excavation has largely resulted from attempts to use them in unfavorable conditions. Expeditious cutting of large-diam. c-i mains is problem for research. Employment of hand- or power-driven rotary cutters still comparatively slow process. Detection of hidden valve covers and locating buried and uncharted mains has advanced to high state of eff. in recent years.—*H. E. Babbitt.*

The Estimation of Extreme Flood Discharges by Statistical Methods. A. D. BENHAM. Proc. N. Z. Inst. of Engrs., **36** ('50). Advocating statistical methods for estn. of future flood flows and their return periods, paper prepared by Benham. Methods especially necessary in New Zealand where river flow records are all of short duration. Three methods are discussed: Foster's and Gumbel's systems, which are based on former river flows, and Sherman's unit hydrograph, which uses rainfall and runoff records. In graphically comparing Foster's and Gumbel's methods, Benham finds little difference in the final results, although Foster's system is more complex. Sherman's unit hydrograph is advocated only as a check on other methods

(Continued on page 58)

On tap:

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A.W.W.A.'s manual of *Water Quality and Treatment* brought up to date, with chapters on: source characteristics; aquatic organisms, quality standards, stream pollution and self-purification, impounding reservoir control, aeration, coagulation, mixing and sedimentation basins, disinfection, taste and odor control, filtration, scale and corrosion control, softening, iron and manganese removal, boiler water treatment, fluoridation, and treatment plant control. With four appendixes and an index, that makes 451 pages.

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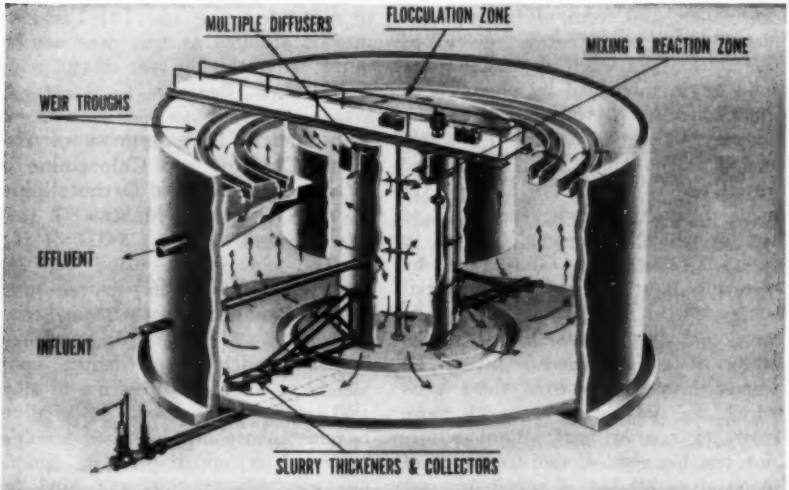

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(Continued from page 56)

due to New Zealand's short rainfall records. Included is table of the max. annual dischgs. of New Zealand's rivers on which results are based.—*D. Noll.*

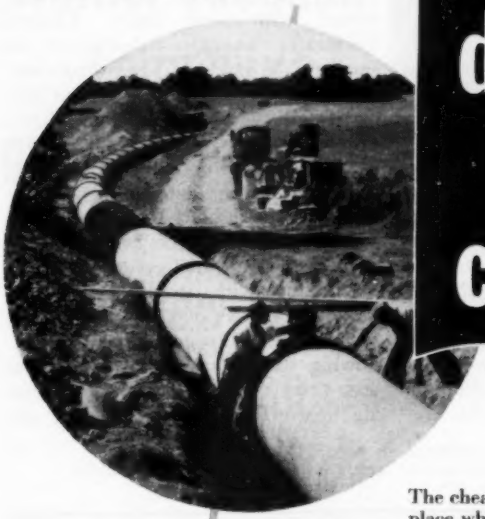
CHEMICAL ANALYSIS

The Analysis of Water by the Assessment of Turbidity. H. E. Rose. J. Inst. Wtr. Engrs. (Br.), 5:521 ('51). Two lines of investigation must be followed through before water anal. by turbidity methods can be developed to high std. of accuracy: [1] establishment of relationship between light-absorbing and light-scattering properties of suspension and phys. and chem. properties of material in suspension, and [2] establishment of relationship between phys. and chem. properties of substances in suspension and characteristics of water to be assessed. Before turbidity measurements can be made accurate and reproducible test of water qual., agreement must be reached on: [1] phys. dimensions and form of std. turbidimeter (careful attention given to points of design such as limitation of solid angle subtended by photocell to practical min., [2] form of test to be adopted. Light scattering by water sample is sometimes used as basis of visual test of qual. No attempt yet made to use this property as basis of test in which photometer is used to assess light scattered. Water anal. by metering light scattered by material suspended in sample unlikely to be developed into routine method, as study of eq. involved indicates no means of obtaining from these tests which are not obtainable much more easily by opacity tests. Photoextinction test for detn. of size frequency of material suspended in water has received little attention. Method may be extended to give complete data on material suspended in sample. Data obtainable without recourse to gravimetric anal., which, for concns. of material encountered in water anal. would be troublesome. Optical properties of colored solns. in which color arises from colored ions probably not governed by laws such as those considered. Care should be taken to avoid application of methods discussed to assessment of properties whose detn. correctly falls within realm of colorimetry. Quals. such as filtrability length of filter life associated with particular water would depend mainly on concn., size, distr., and similar characteristics of material in sample. As methods discussed assess these characteristics, results of turbidity tests can be expected to give accurate information on these quals. [1] Tests for assessment of turbidity do not give unique value for size characteristics of suspended material. [2] Turbidity test cannot give accurate value of product of concn. and one-quarter of specific surface of suspended material. [3] Turbidity method may be extended to give complete anal. of suspended material. [4] Turbidity method absolute as app. does not require calibration by use of std. powders.—*H. E. Babbitt.*

Photometric Measurement of Residual Chlorine and Chloramine in Water Using Neutral Orthotolidine. R. W. Aitken & D. Mercer. J. Inst. Wtr. Engrs. (Br.), 5:321 ('51). Method consists of using o-t and hexametaphosphate in neutral soln., slightly modified to assure more careful control of pH at 6.3. Alternate method, which elimd. fading completely in 4 min, involves use of alkyl aryl sulfonate instead of sodium hexametaphosphate. Method involves buffering to approx. pH 7.0. Simple photoelec. colorimeter was used for all measurements. Blue meriquinone color developed given spectrophotometric anal. Fading occurs at pH 7.04, is greatly reduced at pH 6.33, and still further reduced at 6.04. In-

(Continued on page 60)

IN SYRACUSE, NEW YORK—On this gravity line, joints had to be completely leakproof to prevent possible infiltration of polluted ground water. Syracuse engineers specified a Dresser-Coupled steel line with confidence based on many years of experience with this type of construction.



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(Continued from page 58)

terference of chloramines absent for 4 min with pH more than 6.3. Interference becomes marked at pH 5.6. As pH 6.3 was selected as most suitable, phosphate buffer to hold this pH prepared. Color produced with potassium iodide not identical to that obtained with chlorine. For photometric detn., was desirable for absorption of two colors to be same. In practice, tricolor green filter gave satisfactory results, but sensitivity was reduced. Sodium hexametaphosphate satisfactory dispersing agent at pH 6.3 if sample is viewed in less than 1 min. Alkyl aryl sulfonate gave improved results. Elimd. fading entirely within 4 min. Agent not suitable for use with volumetric technique. All titrations run in parallel with colorimetric measurements must be done on separate samples.—*H. E. Babbitt.*

ALGAE CONTROL

Freshwater Biological Research and Water Supply. W. H. PEARSALL. J. Inst. Wtr. Engrs. (Br.), **5**:482 ('51). Freshwater biologist concerned with food chain. Largest freshwater animals—fishes—feed on smaller fish, insect larvae, water-fleas. Each in turn feeds on others, but ultimately all derive food from plants. Plants pose new set of problems such as, in presence of light, they convert inanimate matter into living matter. Origins of dissolved mineral substances extremely complex. Knowledge of these diverse systems valuable in dealing with storage reservoirs. Dissolved matter like trap in drainage system. Sol. nitrogen content of outflowing stream has been shown to be less than that of feeder. Vigorous algal growth may reduce total salt

(Continued on page 62)

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(*Continued from page 60*)

content or hardness of water as much as one-third. Difficulties that result from plant growths are not confined to those of filtration. Design of reservoirs may lead to great difficulty if heavy algal growths are expected. Any reservoir tends to get thermally stratified. At top is warm, illuminated layer, the epilimnion, and below 30 ft is the hypolimnion. Latter remains out of contact with air and light. Difficulties probable in southeastern England where ratio of epilimnion to hypolimnion water exceeds 10:1. With this ratio, reservoir will only go out of use occasionally in summer for 2–3 wk after continued strong winds. Shallow reservoirs are open to objection that plants grow freely on sloping sides, especially as water falls. Remains decomposed to give still heavier algal growths.—*H. E. Babbitt.*

Effects of Algae on Water Supply. W. J. CHAMBERLAIN. Dept. of Chem., Univ. of Queensland (Australia), Bul. 1:29 ('48). Survey made of literature on growth, occurrence, and control of algae in water supplies. Algal groups known to produce objectionable tastes and odors listed; photographs given of those which commonly occur in Brisbane water supplies. Investigations on role of algae in the pptn. of calcium and magnesium salts in relation to their effect on filtration of water at Brisbane described. Eq. representing the equil. existing between carbon dioxide and its derivatives in natural waters given and from them eq. derived from which, by detg. the pH value and concn. of titratable base, the other equil. constituents can be computed. The derived eq. have been used in detg. changes which take place in raw water during passage through slow sand filters in which prolific growths of *Spirogyra, Cladophora,* and *Zygnema* occur. Results showed, when water which was undersaturated with calcium carbonate was applied to filters in which algae were actively growing, supersaturation was rapidly established above the sand surface where floating masses of *Spirogyra* occurred. Calcium carbonate was deposited within the filter, and, as a result of deposition and respiration of bacteria and algae, effluent was undersaturated. During period when filters were being examd., it was estd. that the 10 filters contained approx. 30 tons of deposited calcium carbonate and 12 tons of magnesium hydroxide. When turbidity of raw water is high prelim. coagulation with aluminium sulfate given. During passage through filter, pH value of settled coagulated water increased from 5–6 to 7.0–7.5 owing to presence of deposited carbonates. As a result of algal activity, appreciable reductions have been made at Brisbane in the consumption of soda ash and hydrated lime, which are added to the filter effluent to prevent corrosion in the distr. system. Is necessary to control carefully amt. of aluminium sulphate used in coagulation, as aluminium ions may react with deposits to produce aluminium hydroxide, which forms a gel and chokes the filters. Deposits on leaves of various aquatic plants which grow in Brisbane River and its tributaries examd. Deposits consisted mainly of calcium carbonate; deposits on *Hydrilla* contained up to 5% magnesium hydroxide and deposits on *Potamogeton* contained about 18–23% magnesium carbonate. Lab. expts. made on changes in water effected by actively growing plants. Results given in tables show a regular increase in pH value during photosynthesis with a decrease overnight from bact. and algal respiration. There was a progressive decrease from day to day in titratable base with an overnight increase due to the redissolving of pptd. base. Anals. of various naturally occurring carbonate deposits given and discussed in rela-

(*Continued on page 64*)

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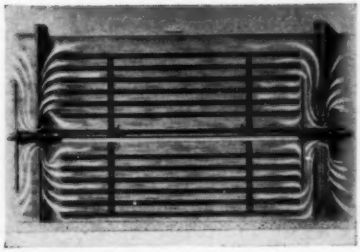

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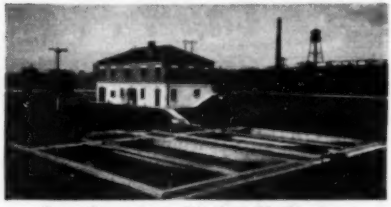

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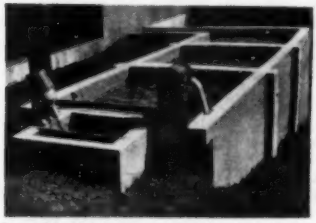

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(Continued from page 62)

tion to photosynthetic activity and carbonate equil.—*W.P.A.*

Chemical Composition of Algae and Its Relationship to Taste and Odor. G. A. ROHLICH & W. B. SARLES. Taste & Odor Control J., **18**:2 ('49). Algae frequent cause of taste and odor in water supplies. Many algae have definite odors while alive, and other odoriferous compds. may be formed by the action of bacteria on dead algae. Type of odor caused by various organisms. Chem. compn. of some of these shown in tables. Is suggested that actinomycetes often found in lakes may also cause tastes and odors. These have an earthy odor, and their action on decomposing algae may produce odoriferous compds. different from those produced by bact. action.—*W.P.A.*

FOREIGN WATER SUPPLIES (GENERAL)

Water Supply of Teheran. G. KNOWLES. J. Inst. Wtr. Engrs. (Br.), **5**:285 ('51). Pop. of Teheran approx. 900,000. City approx. 4,000 ft above sea level. Water drawn mainly from R. Karaj. Water flows from river by gravity in canal, partly in open and partly in tunnels, to northern boundary of city. Distributed throughout city by network of open street channels, called "jubes." Limited quant. of clear water for drinking obtained from "kanauts" (tunnels tapping underground sources in foothills and bringing water to surface at approx. 20 points in city). Vessels may be brought to kanaut delivery points for filling. Small amts of water, not available to public, obtained from pri-

(Continued on page 66)

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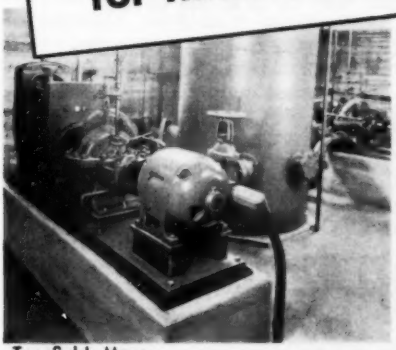
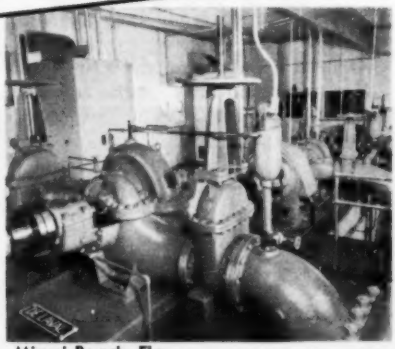
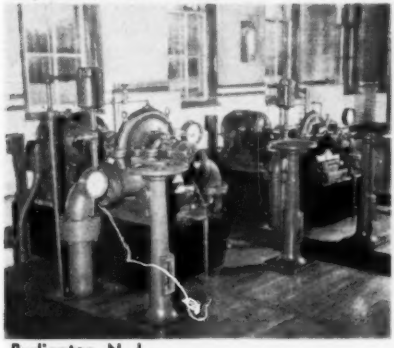


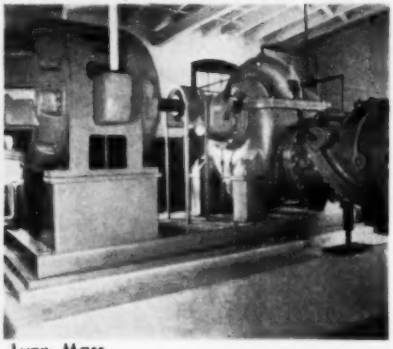
Topsfield, Mass.



Miami Beach, Fla.



Burlington, N. J.



Lynn, Mass.

Here are four typical De Laval centrifugal pump installations that will keep giving efficient, continuous service for years to come. In fact, since the turn of the century De Laval water works pumps have been serving both big cities and small towns throughout the nation. These pumps are available in capacities ranging from less than one mgd to more than 100 mgd.

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(Continued from page 64)

vate wells in city. Examn. of R. Karaj water showed that addn. of coagulants would be necessary for removal of solids. Lab. expts. made to find best coagulant. Most promising and best avg. doses: aluminoferric (10 ppm) added simultaneously with colloidal silica (4 ppm expressed as SiO_2); sodium aluminate (10 ppm) added simultaneously with colloidal silica (10 ppm); ferric chloride (10 ppm). Pilot plant expts made to compare suitability of horizontal-flow sedimentation tanks and upward-flow sedimentation tanks of sludge-blanket type with coagulants, and to est. vols. of sludge deposited and amts of water lost in sludge. Calcns. based on Hoover's modification of Langelier's eq. showed that there would always be tendency for R. Karaj water, after coagulation and filtration, to be undersatd. Addn of alkali may be necessary to prevent corrosion in distr. system.—*H. E. Babbitt.*

Radio Communication Installation at Southend. ANON. Wtr. & Wtr. Eng. (Br.), **55**:286 ('51). Area of supply of Southend Waterworks Co. 200 sq. mi. Pop. approx. 252,000. Avg. daily supply over 7 mil gal (Imp.). In predominantly rural area, 615 mi of mains often follow country roads or are laid across fields difficult to reach. Communication difficult. Responsible officers at various points. Each has car equipped with mobile, ultrahigh-frequency transmitter-receiver. Head office at Southend has fixed, transmitter-receiver installation. Head office equip. can ring bell in any mobile unit without calling others. Any mobile unit can communicate with any other. Mains supt. can maint. contact both with head office and with any mobile units in his round. Equip. useful in company's mobile office for collecting rates and dealing with consumers queries which can be referred to head office and settled on spot. Fixed station is rack assembly which houses transmitter, receiver, and control unit. Transmitter crystal controlled. Has frequency of 85.325 megacycles and nominal power of 25 w. Receiver also crystal controlled. Operates on frequency of 71.825 megacycles. Double superheterodyne with sensitivity of 1μv, fitted with automatic muting circuit. Mobile equip. compact and light. Power consumption at 12 v. is 3 amp when receiving and 5.5 amp when transmitting.—*H. E. Babbitt.*

The Big Eildon Project in the State of Victoria, Australia. C. C. TWELFTREE. Wtr. & Wtr. Eng. (Br.), **55**:313 ('51). Work begun on great water conservation project which, by constr. of large earth dam across Goulburn R. to form reservoir of 750,000 mil gal (Imp.) capac., will double Goulburn irrig. system, already largest in Australia, and feed new 120,000-kw power station, to be largest in Victoria. Cost of dam will reach almost £12,000,000, Australian. Largest contract ever entered into by single Australian contractor. Contractor is Utah Construction Co., San Francisco, Calif. Earth and rock in embankment will be 13,000,000 cu yd. Dam to be built in 4 yr and 36 wk from June 15, '51.—*H. E. Babbitt.*

DISTRIBUTION SYSTEMS

Prestressed Concrete Tanks at West Hartlepool. ANON. Wtr. & Wtr. Eng. (Br.), **55**:321 ('51). Five tanks recently completed claimed to be first of prestressed concrete ever constructed in England. Magnel-Blaton system of prestressing employed. Two tanks, 106 ft in diam and 41 ft deep; one, 50 ft in diam and 46 ft 6 in. deep; and two are 30 ft in diam and 36 ft deep. Tank walls made thicker than required by working stresses in concrete, as these were

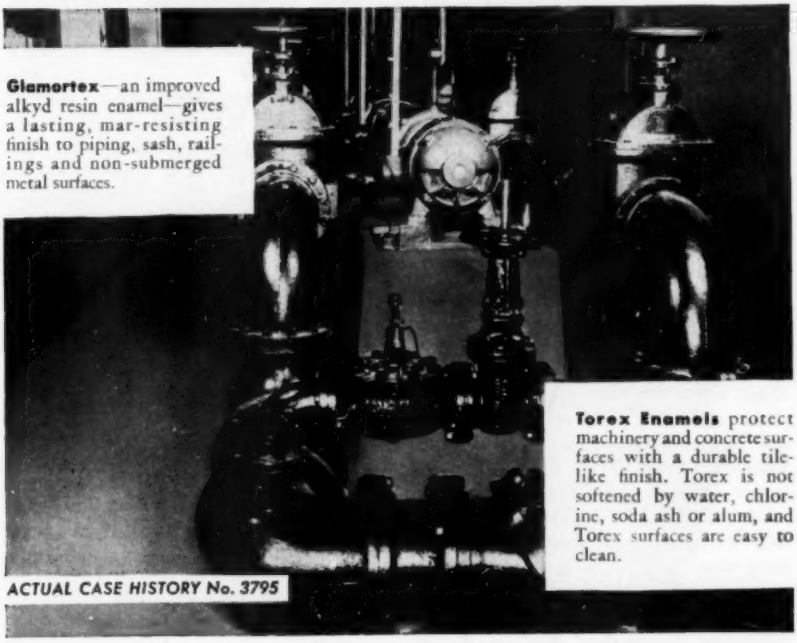
(Continued on page 68)

Engineers Havens and Emerson

specify

INERTOL PAINTS

throughout Cleveland water plant



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(Continued from page 66)

first tanks of type built in England, and was desired to permit concrete to be placed and compacted easily. Stresses are much less than generally used in prestressed concrete design. Sequence of prestressing was to tension first vertical cables and then horizontal ones to assure tensile stresses due to temporary vertical movements caused by horizontal pressure operation were counteracted by vertical prestressing. No horizontal cracking would occur. Tanks designed with sliding joint between walls and base. Joint formed by constructing groove in base and casting wall in it. Prestressed shell of 106-ft diam tank is 35 ft high, 11½ in. thick at bottom, and tapers to 6 in. thick at junction with top rim. In 50-ft diam tank, shell is 10 in. thick at bottom, tapering to 6 in. at top in height of 40 ft. In 30-ft diam tank, thickness varies from 9 in. to 6 in height of 36 ft. Vertical reinforcing cables made of 0.200-in. diam wires, of 100–110 tons psi ultimate strength, tensioned to 140,000 psi. Horizontal reinforcing cables composed of 0.200-in. diam wires for upper cables, and of 0.276-in. diam wires, of 95–105 tons psi ultimate tensile strength near bottom. Concrete mix was 1:1½:3 with water-cement ratio of 0.45.—*H. E. Babbitt.*

Thermal Protection Against Frost. A. W. NEAL. J. Inst. Wtr. Engrs. (Br.), **5**:294 ('51). Although adequate safeguards against frost usually offered by conventional forms of antifreeze coatings and pipework layout, difficulty experienced in exceptional cases or where desired to elim. all risk. Some highly specialized and ingenious schemes devised in aircraft industry for preventing and dissipating ice accretion. Devices could, with appropriate modification, be applied as antifrost measures in pipework. Deicing airscrews accomplished by film heaters bonded to leading edge of blade and supplied with elec. energy from plane's batteries. Certain flexible resins used successfully for deicing. Sandwiches of thin metal foils could also be used. Methods of lagging human frame by means of elec. heated textiles provide another approach. Underground soil-heating cable designed for garden frames and hot beds. Success of cable led to introduction of cable designed to prevent freezing of domestic water systems. All these devices lend themselves to thermostatic control. Pipes rising from buried mains need careful protection so water can flow back into main. Development of ice plug may seal exit. Unlikely elec. method of frost protection can be developed to degree of eff. obtainable by established methods. Reasonably eff. and cheap protection may be achieved for special cases.—*H. E. Babbitt.*

DISINFECTION

The Disinfection of Water Mains After Laying and Carrying out Repairs. E. WINDLE TAYLOR & L. C. WHISKIN. J. Inst. Wtr. Engrs. (Br.), **5**:219 (May '51). Water may become contamd. in mains from water and mud in trench, jointing materials, workmen, new pipes, disturbance of silt in old mains. Tracing of outbreak from main poln. should not prove difficult if spot map is used to show scatter of cases. From 1911–37 in Great Britain, 20 outbreaks were reported. From 1938–45 three were reported in U.S. Some types of *coli-aerogenes* bacteria will persist and even thrive on certain materials used in water works. At certain temps., bacteria actually multiply on jute yarn. Precautions to maint. purity of water are: [1] all operating personnel be examd. to exclude carriers of water-borne disease; [2] constr. workers instructed in hygiene of mainlaying and main disinfection; [3] keep stocks of pipes clean;

(Continued on page 70)

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(Continued from page 68)

[4] when constr. is suspended, close mouth of last pipe; [5] prevent flooding of trench; [6] use only clean and sterile joining material; and [7] disinfect mains before they are put into supply. First reference to main disinfection was made in America in 1926. Polg. matter should be prevented from entering mains. Mains should be thoroughly flushed before disinfection. Chlorination can be effected with bleach powder, sodium hypochlorite solns., gaseous chlorine. Dry bleach powder is placed in each pipe as it is laid. Slurry of bleaching powder can also be poured into main at hydrant outlet. Slurry is washed with few bucketfuls of clean water. Main then charged. Another method is application of chlorine gas to charging water by soln.-feed chlorinating device or gas fed directly from chlorine cylinder. Opinions vary on amt. of chlorine to be used up to 100 ppm. Whole section of repaired main should be emptied before chlorination. Penetration of disinfectant to all parts is certain only if charging water is chlorinated as it enters main. Contact period should be long enough to destroy all non-spore-forming bacteria. Although 24 hr often allowed, 2 hr should be sufficient. After contact period and thorough flushing, water anal. should be made. If main water is believed pold., consumers may be advised to boil water or should be supplied from standpipes on alternative mains or by water tankers. Statistical anal. of mains repaired and disinfected by Metropolitan Water Board early in World War II showed marked difference in eff. of methods of disinfecting large and small mains. Method of applying chlorine to small mains was less efficient because: [1]

(Continued on page 72)

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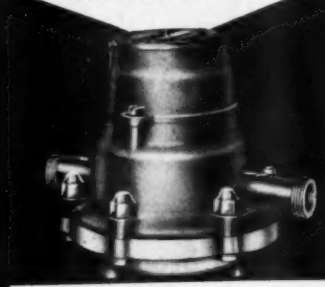

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(Continued from page 70)

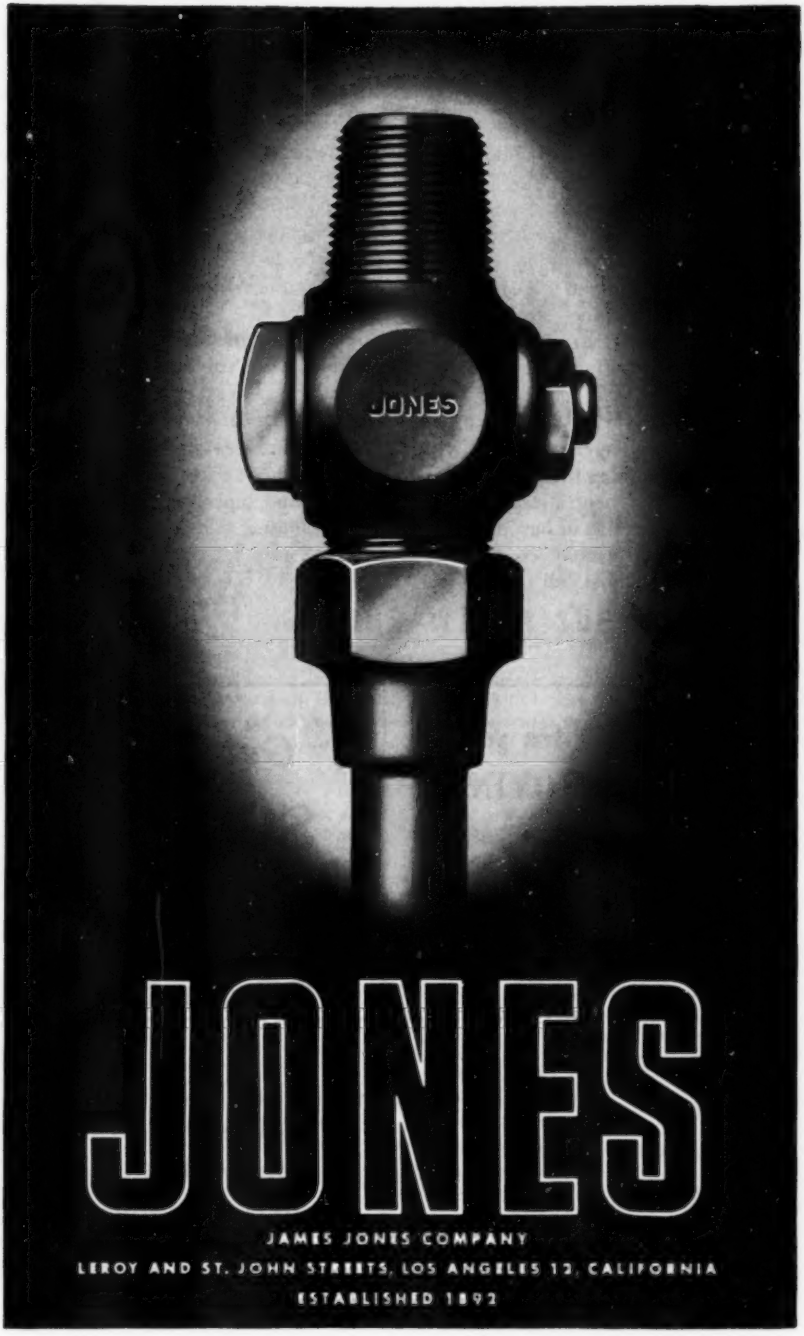
distr. of chlorine was uneven from more complicated layout of small mains, as they are rarely laid to uniform gradients or provided with proper emptying apparatus, and treatment of branch connections and service pipes was ineffective; [2] jute yarn injected in making joints; [3] foreign matter entered pipes during laying; and [4] personnel had less experience than those chlorinating large mains. Ends of exposed main in trench and new pipes should be wet with sodium hypochlorite soln. Flushing before chlorination forced contamn. into service pipes and storage tanks on consumers premises. Simple apps. required to charge water automatically, and continuously dose it with required amt. of chlorine. Probable causes of failure to disinfect small mains effectively seemed to be: disturbance and infection of silt in main, infection by mud and water from trench, and infection from jute yarn used in making bell-and-spigot joints. Alternative materials for making such joints are solid lead, leaded-jute yarn, lead-jute yarn lead, and asbestos cement. Alternative to bell-and-spigot joint is one or other type of many flexible joints now available. Substitutes for jute yarn are rubber, compressed paper, and treated rayon. Jute yarn may be sterilized by steam, chlorine, copper and mercury, quaternary ammonium compds., and tar. Mercury treatment achieved complete sterility and mercurial compd. remained firmly attached to jute fibres and continued to exert bactericidal action. Lab. control of chem. treatment of jute yarn is essential. If mercury content of material does not exceed approx. 0.15% only occasional insignificant trace of mercury will diffuse into water. Reports on experience and present practice are given for Australia, Belgium, Canada, China, Eire, Great Britain, the Netherlands, Nigeria, and Switzerland.—*H. E. Babbitt.*

SERVICES AND METERS

Breakdown of Copper Water Piping. *Misc. Pub. 420.* British Non-Ferrous Metals Research Assn., London ('50). Two types of corrosion of copper water pipes observed. One is slight uniform corrosion occurring where the water contains a high proportion of free carbon dioxide; this causes green staining found in baths but does not appreciably reduce useful life of pipe. Other type is pitting caused by a few British water supplies. Pitting in hot-water pipes caused by some soft, moorland waters, that in cold-water pipes, by moderately hard, bore-hole waters. Most water supplies contain natural inhibitor which prevents pitting. Inhibitor not identified and may vary in different waters. Detns. made of the amt. of carbon in scale deposited in 104 corroded copper tubes and on seventeen uncorroded tubes taken from service in areas where pitting occurred. Close correlation was found between amt. of carbon present and incidence of pitting in cold-water pipes. Of 80 corroded cold-water pipes, scale of 63 contd. more than 1.0 mg of carbon per sq decimeter and seven had less than 1.0 mg per sq decimeter. In scale from thirteen unpitted pipes examd., never more than 1.9 mg of carbon per sq decimeter was present, and, in twelve pipes, less than 1.0 mg per sq decimeter was found. Correlation between presence of carbonaceous films and occurrence of pitting in hot-water pipes is less definite. Results of investigation given in a table.—*W.P.A.*

Protective Coatings in Lead Pipes From Very Soft Water. JOHANNES MULLER. Gesundh. Ing. (Swiss), **71**: 325 ('50). Value of protective coatings in lead pipe is uncertain and depends on amt. of lead which may be permitted in the water from standpoint of health, and possibility that this

(Continued on page 74)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(Continued from page 72)

limit may be exceeded because of unforeseen circumstances. A soft-lead pipe used with a very soft, treated H_2O of low alky. quickly developed very good protective coating which caused a negligible lead content in stagnant H_2O, while an acid, untreated H_2O with little free CO_2 developed an appreciable lead content. Coating remained pore-free when treated with oxygenated, CO_2-free, distd. H_2O. Protective coatings not long in contact with the treated H_2O quickly lost their eff. when treated with aggressive raw H_2O. Coatings longer in contact with treated H_2O retained their eff. longer, so that occasional neutralization of the H_2O would not result in harmful amts. of lead. The protective coating was found to be almost all $PbCO_3$ or $2PbCO_3.Pb(OH)_2$, with some $Pb_3(PO_4)_2$ and $PbSiO_3$. The silicate in combination with the basic carbonate considered important for good protective properties. There is a possibility that an ext., thin, lead-rich layer found on the coating could come loose in household piping and form a suspension harmful to health.—*C.A.*

The Control of Stray Currents and the General Problem of Protecting Pipes. A. WEILER. Bul. Centre Belge et Documents Eaux (Belg.) ('50). Discusses origin of stray elec. currents, their effect on corrosion of underground pipes, and methods used for preventing this type of corrosion. Other causes of corrosion of buried pipes briefly reviewed.—*W.P.A.*

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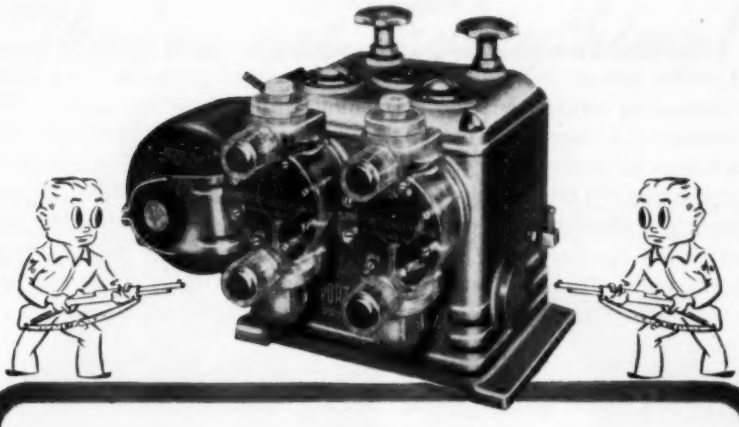

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(Continued from page 18)

Plotting droughts sounds subversive, but it's really a strictly statistical pursuit devised by Dr. E. J. Gumbel of Stanford University as a means of forecasting future dry spells. Defining a drought as the smallest daily discharge of a river for a certain year, Dr. Gumbel plots minimum daily discharges for a number of years to discover a statistical distribution of extreme values. Then, based on the mathematical concept involved, he constructs a probability paper on which the values are plotted as straight lines that permit the forecasting of the severest drought in any period. If we slightly fumble Gumbel's jumble of mathematical statistics, you'll just have to take our word for the fact that this method can be important in water supply planning.

While we're mathematting, though, we mustn't fail to report our discovery, at long last, of a formula that has all the appearances of being intelligible. The place: Ivan E. Houk's new *Irrigation Engineering,* Vol. 1. The formula: $Q = ASK$. Of course, Dr. Houk feels obliged to explain that this is the formula by which amounts of flow through permeable materials are usually calculated and that Q is the quantity of water moved through the cross section of permeable material per unit time, A is the area of the cross section, S is the hydraulic slope, and K is a constant depending on the particular characteristics of the permeable material. Wouldn't it have been clearer to counterpose $A = REPLY$, in which all terms depend entirely on the Q you ASK?

A change in federal income tax laws, as proposed by the Byrnes bill (H.R. 5474) before the House Ways & Means Committee, is being backed by the Ohio River Valley Water Sanitation Commission. The bill, which would permit a quicker write-off of costs for constructing waste treatment plants, is believed by the commission to offer an incentive to industries to clean up streams. The commission pointed to the precedent under which private enterprise is being stimulated to construct defense plants by a similar acceleration of amortization.

Virgil W. Langworthy, formerly with the Lansing, Mich., Water Conditioning Plant, has accepted the post of research chemist with the Chlorine Inst. of New York. He succeeds Harry A. Faber, who is now with *Water & Sewage Works* magazine (*see* December 1951 P&R, p. 8).

S. K. Velliquette has received a temporary appointment—pending a Civil Service examination—to the post of director of new business and statistics for the Los Angeles Dept. of Water & Power. He is a veteran of 30 years with the department, the last 10 with the section he is now to head.

(Continued on page 78)

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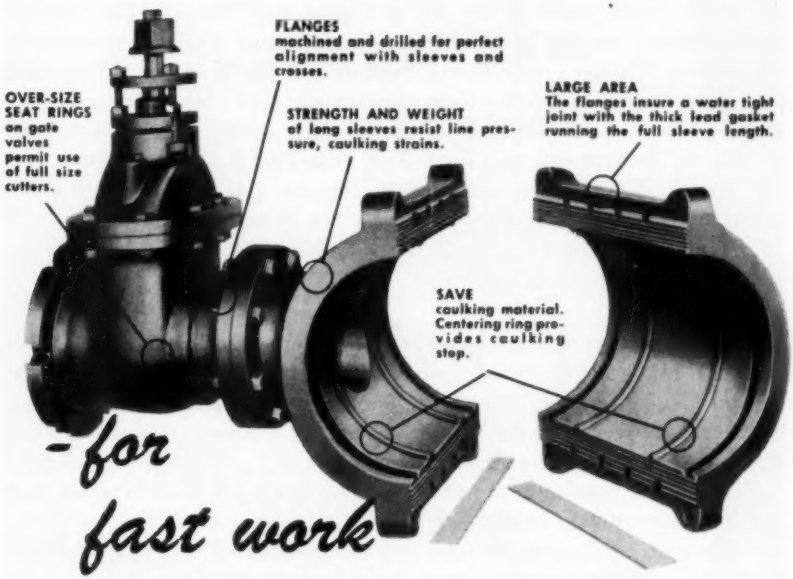
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(Continued from page 76)

Water's wonderful works again: Snow Basin, Utah, one of the finest natural ski bowls in the country, owes its development to the fact that the public water supply of the city of Ogden was "dirty." The dirtiness was caused by erosion in the basin, the sediment of which was carried by runoff into Wheeler Creek, one of Ogden's sources of supply. To protect its supply, the city bought the basin and turned it over to the National Forest Service for the development of erosion control works. And with this introduction, the area was soon discovered to be ideal for a winter sports center. Now, in addition to clean water, the city gets a tidy sum from its operation of the first municipally owned chair lift in the West.

There isn't much hope for Miami in this, but we sure aren't above putting a bug in New York City's ear.

A bitter cup it was, quite literally, from which Bob Hansen, Mt. Clemens, Mich., water superintendent quaffed last month. A complaint of bad taste at a local drug store soda fountain brought him running. A sip of the supply served at the fountain gave him a strong, distinctly chlorophenol jolt and sent him running. A check of taps at neighboring buildings registered total tastelessness and slowed him down. A *glass* of water from the fountain—eureka, he stopped!

The clue, for those of you who long since graduated from soda fountains, is simply that most fountains serve water to their customers in paper cups. This one did. And when Mt. Clemens water, carrying a chlorine residual of 1 ppm, was brought into contact with the paper, a taste was produced—a taste that increased in strength with time of contact. Although water of a lower chlorine residual was found to be less affected, the taste was still noticeable.

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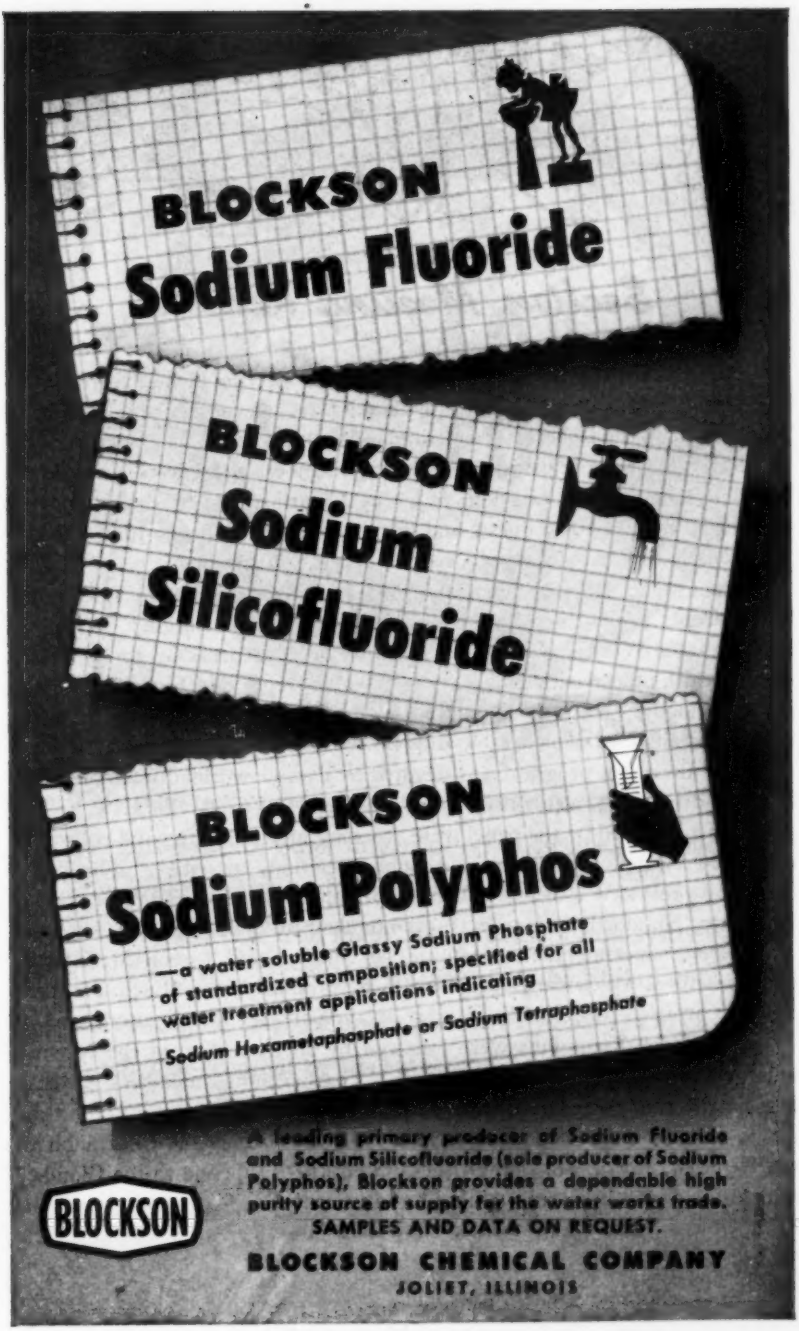
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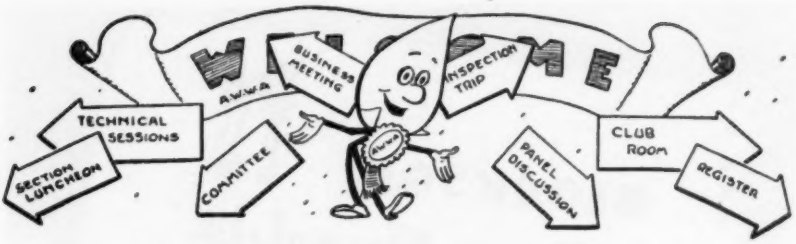


Section Meeting Reports

North Carolina Section: The 31st annual meeting of the North Carolina Section was held jointly with the North Carolina Sewage and Industrial Waste Assn. at the Robert E. Lee Hotel in Winston-Salem on November 12–14, 1951. The total registration, including members and guests, was 242.

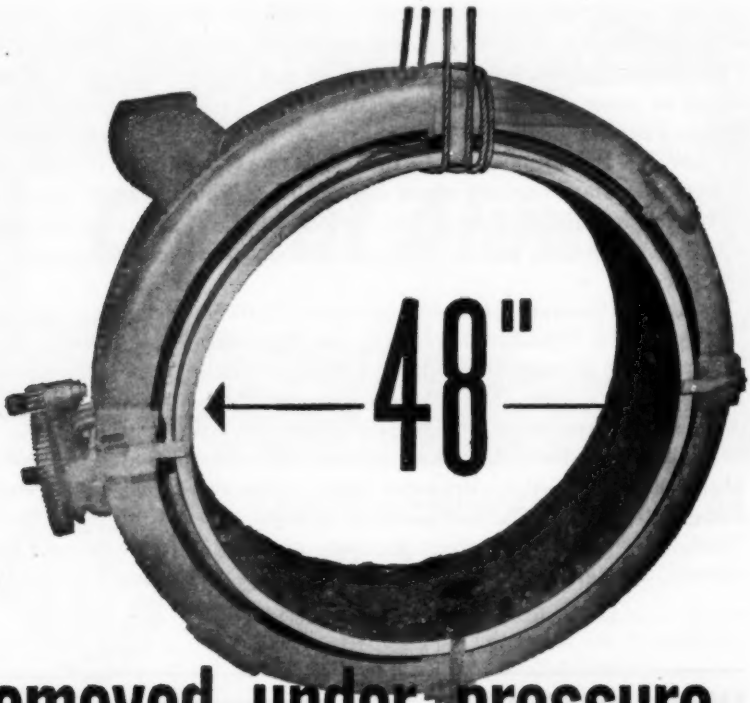
The meeting was called to order by Chairman W. W. Adkins, who recognized distinguished guests and introduced City Manager John Gold of Winston-Salem, who delivered a cordial address of welcome.

Stanford E. Harris, superintendent of the Winston-Salem Water and Sewer Dept., began the technical program with a paper entitled "Winston-Salem Water Works." This was followed by an address by Z. M. Stadt, dental health officer with the Charlotte Health Dept., on "Fluoridation Results From the Dental Viewpoint." Both subjects were excellently presented and aroused considerable interest.

The afternoon program was devoted to a water works discussion panel led by W. E. Long, water plant superintendent at Fayetteville, N.C. The subjects considered by the panel were: reading meters, billing and collecting bills, and related accounting and public relations activities. The panel members were: W. M. Franklin, superintendent of the Water Dept., Charlotte; Stanford E. Harris, superintendent at Winston-Salem; Robert Van Sleen, superintendent of utilities at Shelby; and Joseph M. Owens, superintendent of water and sewage at Mount Airy. Each of these subjects aroused considerable interest on the part of those in attendance.

The panel discussions were followed by an inspection of the recently enlarged Winston-Salem water plant. That evening, members of both associations and their wives were entertained at a buffet supper given by a group of local contractors. Following this function, W. W. Farinholt of the General Electric Co. showed the film entitled "Pipeline to the Clouds," which was found both entertaining and instructive. The remainder of the evening was taken up by a floor show and informal dance staged on the Balinese Roof of Hotel Robert E. Lee.

(*Continued on page 82*)



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(*Continued from page 80*)

The morning session on November 13 was opened by a paper entitled "Disposal of Radioactive Wastes in Water and Sewage" by Roy J. Morton, leader of waste disposal research, Oak Ridge National Laboratories, Oak Ridge, Tenn. The subject, "Maintenance of Water Quality," was presented by AWWA President Albert E. Berry of Toronto, Ont. H. G. Baity, professor of sanitary engineering at the School of Public Health, University of North Carolina, discussed "The New North Carolina Stream Sanitation Law." All of these papers and addresses were excellently presented and well received.

At the Honorary Luncheon for national officers and guests, addresses were given by President Berry and also President Earnest Boyce of the Federation of Sewage and Industrial Wastes Associations. The luncheon was followed by the annual business meeting, at which reports of committees were received and officers for the ensuing year were elected.

The remainder of Tuesday afternoon was devoted to a Sewage Works Discussion Panel led by Brewster Snow, professor of civil engineering at Duke University. The subjects and authors were: "Financing Sewage Works" by W. E. Easterling, secretary of the Local Government Commission, Raleigh; "Increasing Costs of Sewage Treatment" by Carl W.

(*Continued on page 84*)

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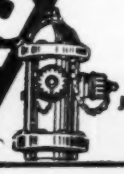

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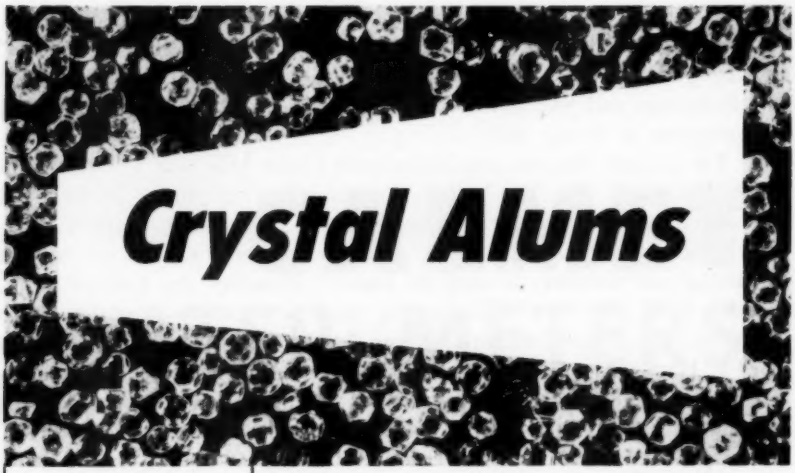

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(Continued from page 82)

Mengel, consultant with W. C. Olsen, Raleigh; "Purchasing of Supplies" by George S. Moore, superintendent of utilities at Albemarle; and Disposal of Screenings and Sanitary Land-Fill Operations" by Felix H. Doggett, city engineer at Mount Airy.

The Annual Banquet and Association Dance was held Tuesday night with Chairman W. W. Adkins presiding. The Maffit Membership Cup was not given this year because it was the opinion of the association officials that no one person had exerted sufficient efforts toward obtaining new members to earn the honor. However, the Ludlow Membership Cup, given for obtaining the most new members in the North Carolina Sewage and Industrial Waste Association, was awarded to Stanford E. Harris, superintendent of water and sewerage department, Winston-Salem. George S. Moore, superintendent of utilities at Albemarle, was nominated to be the recipient of the George Warren Fuller Award. Tully D. Blair, president of the Security Life and Trust Co., Winston-Salem, delivered the principal address of the evening, and proved a stimulating and entertaining speaker.

The program on Wednesday morning consisted of very interesting and informative papers and discussions on waste treatment. The papers

(Continued on page 86)

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(Continued from page 84)

presented were: "Waste Treatment—An Important Element in Industrial Plant Location," by Truman H. Safford of Charles T. Main, Inc., Charlotte; and "Biochemical Oxygen Demands of Chlorinated Sewage," by W. Brewster Snow, professor of civil engineering at Duke University. Discussion of the latter paper was offered by A. E. Griffin, research engineer with the Wallace and Tiernan Co., Inc., Newark, N.J. D. M. Williams, superintendent of the Water and Sewer Dept., Durham, presented a paper entitled "Service Charges in Relationship to Sewage Financing" which was originally scheduled on the program for Tuesday morning but had to be delayed because of a shortage of time.

The Club Room was provided by the manufacturers, as in the past, and constituted a very popular phase of the program. The ladies were entertained at a luncheon on Tuesday, followed by a tour of interesting points in Old Salem and an informal tea at Salem Tavern, in addition to the Buffet Supper on Monday evening and the Annual Banquet and dance on Tuesday evening.

E. C. HUBBARD
Secretary-Treasurer

New York Section: The annual Midwinter Luncheon Meeting of the New York Section was held at the Park Sheraton Hotel, New York City, on Tuesday, Jan. 15, 1952. This meeting for several years has been held in honor of the visiting Directors of the Association who hold their Annual Meeting at that time.

The main features of the January 15th meeting were the stimulating talks given by Willard Chevalier, executive vice-president of the McGraw-Hill Publishing Co., New York, who discussed the national economy, and Gerald E. Arnold, director of the Water Resources Div., NPA, Washington, D.C., who outlined clearly the status of the Controlled Materials Plan for water works. His remarks were followed by many questions on the subject.

At the business meeting, several committee reports were presented, including one by James C. Harding, commissioner of the Westchester County Dept. of Public Works, White Plains, N.Y., for the Water Resources Committee.

Many New Jersey Section and other outlying section members attended the meeting.

R. K. BLANCHARD
Secretary-Treasurer

Chesapeake Section: The third annual meeting of the Chesapeake Section was held at the Sheraton-Belvedere Hotel, Baltimore, on Oct. 31,

(Continued on page 88)

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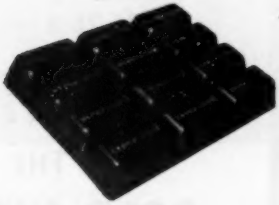

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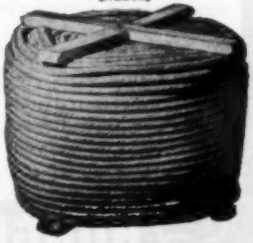

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(Continued from page 86)

Nov. 1 and 2. There was a total registration of 196 members and guests, exclusive of 30 ladies registered and attending the functions arranged for them.

The meeting began socially on Wednesday night, October 31, when the usual "Get-Together" was held in one of the hotel ballrooms. The manufacturers' representatives were hosts at entertainment and refreshments.

On Thursday, November 1, the meeting was formally opened by Chairman David Auld, superintendent of the District of Columbia Water Dept. The popular and enlightening movie "Pipeline to the Clouds" opened the program.

A paper on "Control of Water Quality for Cooling Systems" was offered by M. J. Foley, water consultant for E. I. Du Pont de Nemours & Co., and was discussed by C. S. Bilisoly, of the Potomac Electric Power Co.

A series of three short and highly interesting papers on "Operating Kinks" followed, given by George E. Harrington, chemist, Washington Aqueduct, on chemical problems; John W. Krasauskas, bacteriologist, Washington Aqueduct, on bacteriological innovations; and John M. Jester,

(Continued on page 90)

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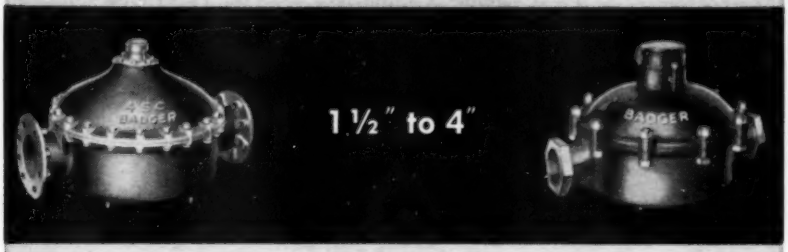

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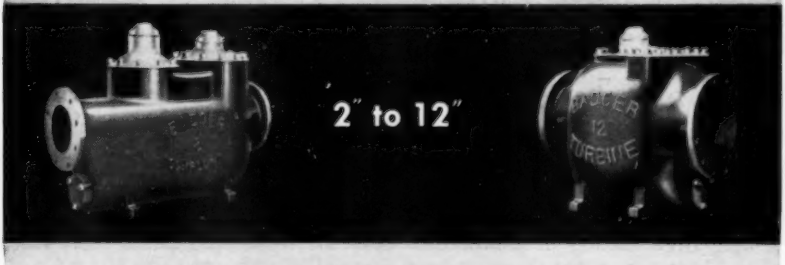

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(Continued from page 88)

maintenance engineer, Washington Suburban Sanitary Dist., on maintenance work.

Harvey S. Howe, former director of Water Resources Div., NPA, discussed "Allocations and Priorities." D. H. Goldsborough, senior associate engineer of Baltimore's Bureau of Water Supply, presented a paper entitled "Maintenance of Distribution Systems." R. S. Jackson, in a paper on "Construction Experiences With Pressure Pipes and Joints," reviewed the experiences of the Washington Suburban Sanitary Dist., with which he is associated as engineer.

A very well attended luncheon followed the morning session. Mayor Thomas D'Alesandro Jr. of Baltimore gave a short but warm welcome to the 138 members and guests. He was followed by an impressive after-dinner talk by Assistant Surgeon General Mark Hollis of the Public Health Service.

The Thursday afternoon meeting was resumed with Chairman Auld presiding. The usual business meeting was first on the agenda, which was then given over to a two-hour panel on "Civil Defense" led by W. J. Warmbold of Baltimore, and featuring discussion by local Baltimore personnel. Thursday's session was then concluded with a short address by national Secretary Harry E. Jordan.

At the Friday morning session was presented a talk on "Membrane Filters in Sanitary Bacteriology" by Harold J. Jeter, Bacteriological Environmental Health Center, USPHS, Cincinnati. This new development was discussed by Charles Phillips of Camp Detrick and John W. Krasauskas, bacteriologist, Washington Aqueduct.

A paper on "Selection and Treatment of Water for Industrial Use" was presented by L. G. von Lossberg, a member of the Sheppard T. Powell consulting organization in Baltimore. Roy H. Ritter, Baltimore consulting engineer, concluded the session with a paper on "The Proposed Ashburton Filter Plant for Baltimore."

On Thursday afternoon the manufacturers association was host to a cocktail party just preceding the very well attended banquet held in the ballroom of the Belvedere. Arrangements Chairman S. C. Blackburn had a very delightful musical entertainment arranged, and a well attended dance program followed.

The ladies attending the meeting were entertained on Thursday at a complimentary luncheon and card party.

The Fuller Award nominee was named at the banquet on Thursday night, but unfortunately the distinguished member and recipient could not be present as he was then in Europe on business. The person named is Abel Wolman, the internationally recognized scholar and sanitary engineer.

CARL J. LAUTER
Secretary-Treasurer

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Peerless Pump Div., Food Machinery Corp.

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Dorr Co.
Morse Bros. Mchy. Co.
Proportioneers, Inc.

Pumps, Hydrant:
W. S. Darley & Co.
Jos. G. Pollard Co., Inc.

Pumps, Hydraulic Booster:
Ross Valve Mfg. Co.

Pumps, Sewage:
Allis-Chalmers Mfg. Co.
DeLaval Steam Turbine Co.
Economy Pumps, Inc.
Peerless Pump Div., Food Machinery Corp.

Pumps, Sump:
DeLaval Steam Turbine Co.
Economy Pumps, Inc.
Peerless Pump Div., Food Machinery Corp.

Pumps, Turbine:
DeLaval Steam Turbine Co.
Layne & Bowler, Inc.
Peerless Pump Div., Food Machinery Corp.

Rate Analysis:
Recording & Statistical Corp.

WORTHINGTON-GAMON

WATCH DOG

The meter used by thousands of municipalities in the U. S.

WATER METERS

"Watch Dog" models . . . made in standard capacities from 20 g.p.m. up: frost-proof and split case in household sizes. Disc, turbine, or compound type.

SURE TO MEET YOUR SPECIFICATIONS FOR ACCURACY, LOW MAINTENANCE, LONG LIFE.

Before you invest in water meters, get acquainted with the design and performance advantages which make Worthington-Gamon Watch Dog Water Meters first choice of so many municipalities and private water companies in the United States.

WORTHINGTON-GAMON METER DIVISION

Worthington Pump and Machinery Corporation

296 SOUTH STREET, NEWARK 5, NEW JERSEY

OFFICES IN ALL PRINCIPAL CITIES

Recorders, Gas Density, CO_2, NH_3, SO_2, etc.:
Permutit Co.
Wallace & Tiernan Co., Inc.

Recording Instruments:
Builders-Providence, Inc.
Infilco Inc.
R. W. Sparling
Wallace & Tiernan Co., Inc.

Reservoirs, Steel:
Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Sand Expansion Gages; see Gages

Sleeves; see Clamps

Sleeves and Valves, Tapping:
James B. Clow & Sons
M & H Valve & Fittings Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.

Sludge Blanket Equipment:
Cochrane Corp.
Permutit Co.

Soda Ash:
Solvay Sales Div.

Sodium Hexametaphosphate:
Blockson Chemical Co.
Calgon, Inc.

Softeners:
Belco Industrial Equipment Div.
Cochrane Corp.
Dearborn Chemical Co.
Dorr Co.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Infilco Inc.
Permutit Co.
Refinite Sales Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.
Worthington Pump & Mach. Corp.

Softening Chemicals and Compounds:
Calgon, Inc.
Infilco Inc.
Permutit Co.
Tennessee Corp.

Standpipes, Steel:
Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Steel Plate Construction:
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Stops, Curb and Corporation:
Hays Mfg. Co.
James Jones Co.
A. P. Smith Mfg. Co.

Storage Tanks; see Tanks

Strainers, Suction:
James B. Clow & Sons
M. Greenberg's Sons
R. D. Wood Co.

Surface Wash Equipment:
Permutit Co.

Swimming Pool Sterilization:
Everson Mfg. Corp.
Omega Machine Co. (Div., Builders Iron Fdry.)
Proportioneers, Inc.
Wallace & Tiernan Co., Inc.
Welsbach Corp., Ozone Processes Div.

Tanks, Steel:
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Tapping Machines:
Hays Mfg. Co.
A. P. Smith Mfg. Co.

Taste and Odor Removal:
Cochrane Corp.
Industrial Chemical Sales Div.
Infilco Inc.
Permutit Co.
Proportioneers, Inc.
Wallace & Tiernan Co., Inc.
Welsbach Corp., Ozone Processes Div.

Telemeters, Level, Pump Control, Rate of Flow, Gate Position, etc.:
Builders-Providence, Inc.

Turbidimetric Apparatus (For Turbidity and Sulfate Determinations):
Hellige, Inc.
Wallace & Tiernan Co., Inc.

Turbines, Steam:
DeLaval Steam Turbine Co.
Worthington Pump & Mach. Corp.

Turbines, Water:
DeLaval Steam Turbine Co.

Valve Boxes:
James B. Clow & Sons
Ford Meter Box Co.
M & H Valve & Fittings Co.
Pacific States Cast Iron Pipe Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valve-Inserting Machines:
A. P. Smith Mfg. Co.

Valves, Altitude:
Golden-Anderson Valve Specialty Co.
Ross Valve Mfg. Co., Inc.

Valves, Butterfly, Check, Flap, Foot, Hose, Mud and Plug:
James B. Clow & Sons
Crane Co.
M. Greenberg's Sons
M & H Valve & Fittings Co.
Rensselaer Valve Co.
R. D. Wood Co.

Valves, Detector Check:
Hersey Mfg. Co.

Valves, Electrically Operated:
Belco Industrial Equipment Div.
James B. Clow & Sons
Crane Co.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Philadelphia Gear Works, Inc.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.

Valves, Float:
James B. Clow & Sons
Golden-Anderson Valve Specialty Co.
Ross Valve Mfg. Co., Inc.

Valves, Gate:
James B. Clow & Sons
Crane Co.
Dresser Mfg. Div.
James Jones Co.
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co.
M & H Valve & Fittings Co.
Pacific States Cast Iron Pipe Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Hydraulically Operated:
James B. Clow & Sons
Crane Co.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Philadelphia Gear Works, Inc.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Large Diameter:
James B. Clow & Sons
Crane Co.
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co.
M & H Valve & Fittings Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Regulating:
Crane Co.
Golden-Anderson Valve Specialty Co.
Ross Valve Mfg. Co.

Valves, Swing Check:
James B. Clow & Sons
Crane Co.
Golden-Anderson Valve Specialty Co.
M. Greenberg's Sons
M & H Valve & Fittings Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Waterproofing
Dearborn Chemical Co.
Inertol Co., Inc.

Water Softening Plants; see Softeners

Water Supply Contractors:
Layne & Bowler, Inc.

Water Testing Apparatus:
Hellige, Inc.
Wallace & Tiernan Co., Inc.

Water Treatment Plants:
Allis-Chalmers Mfg. Co.
American Well Works
Belco Industrial Equipment Div.
Chain Belt Co.
Chicago Bridge & Iron Co.
Dearborn Chemical Co.
Dorr Co.
Everson Mfg. Corp.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Infilco Inc.
Permutit Co.
Pittsburgh-Des Moines Steel Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.
Wallace & Tiernan Co., Inc.
Welsbach Corp., Ozone Processes Div.
Worthington Pump & Mach. Corp.

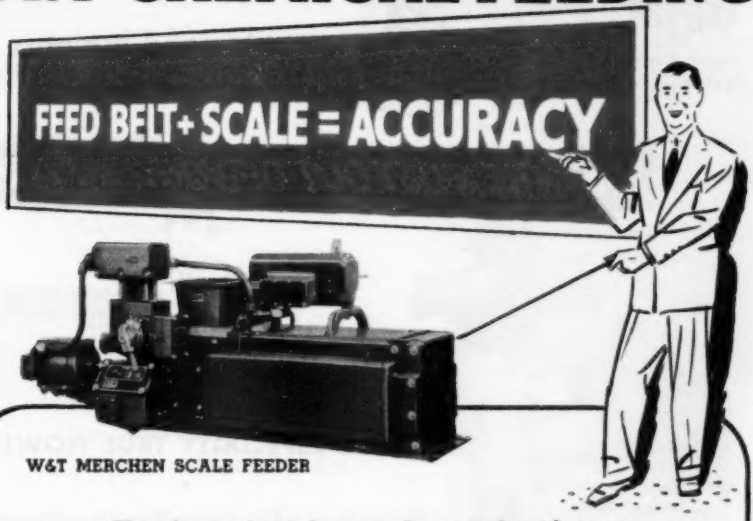
Well Drilling Contractors:
Layne & Bowler, Inc.

Wrenches, Ratchet:
Dresser Mfg. Div.

Zeolite; see Ion Exchange Materials

A complete Buyers' Guide to all water works products and services offered by A.W.W.A. Associate Members appears in the 1950 Membership Directory.

BASIC FORMULA FOR DRY CHEMICAL FEEDING



W&T MERCHEN SCALE FEEDER

This basic formula, supplemented with a new, improved scale beam for controlling the position of the hopper feed gate, ensures the wide range accuracy and dependability which characterize the W&T Merchen Scale Feeder.

For feeding a few pounds or hundreds of pounds per hour, the Merchen Feeder offers these features:

- Continuous feed by weight
- Built-in totalizer
- Totally enclosed motors
- Oil seals on all bearings
- Low maintenance costs
- Trouble-free operation
- Easy feed rate adjustment

Any water works dry chemical — alum, lime, flourides, carbon—can be fed with extreme accuracy by W&T Merchen Scale Feeders. For complete information on Merchen Feeders, write today.

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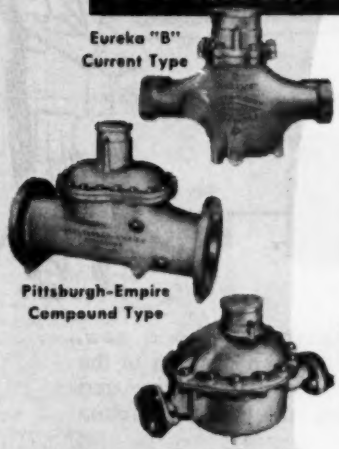
NEWARK 1, NEW JERSEY • REPRESENTED IN PRINCIPAL CITIES

M-16

It's good business at any time to

GET THE MOST OUT OF YOUR METERS



IT'S ESPECIALLY TRUE NOW!

Common sense dictates good meter care. Especially now, with new water meters in short supply it is imperative that existing meters be kept in good condition.

Rockwell meters are easy to maintain; to keep operating at top accuracy. They can be renewed and modernized through the installation of *interchangeable parts*, that in many cases incorporate the latest design advances.

To put new life into your present Rockwell meters, we have built up a larger than normal stock of replacement parts. Your orders for these parts will receive prompt attention. Write today for up-to-date fully illustrated catalogs.

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ROCKWELL
MANUFACTURING COMPANY
PITTSBURGH 8, PA.

Atlanta Boston Chicago
Columbus Houston Kansas City
Los Angeles New York Pittsburgh
San Francisco Seattle Tulsa

KANSAS CITY, KANSAS—30 MGD

what's YOUR water supply problem?

DALLAS, TEXAS—46 MGD

do you have . . .

high turbidity
fluctuating supply
big flow

KANSAS CITY, MO.—150 MGD

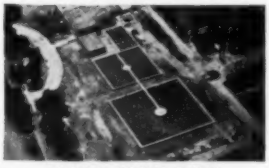
do you want . . .

low cost treatment
standard chemical dosage
common wall construction
low maintenance
minimum operating attention

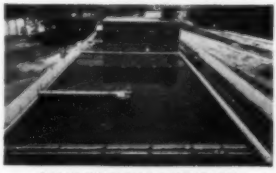
LOUISVILLE, KY.—80 MGD

Specify the Dorrco Flocculator*–Squarex* Clarifier combination

There's no cure-all for every water treatment problem. But for the big jobs, for seasonal turbidities, for low chemical consumption, you can't beat the Dorrco Flocculator in combination with the Squarex Clarifier. Shown on this page are several of the installations where this team has added up to real economy in the water supply field.



WICHITA, KANSAS—45 MGD



HOLLINGSWORTH & WHITNEY CO., MOBILE, ALA.—30 MGD

Details that count! . . .

ON THE DORRCO FLOCCULATOR . . . automatic lubricators for submerged bearings contain a year's supply of grease . . . are actuated by shaft rotation.

ON THE DORRCO SQUAREX CLARIFIER . . . corner blades on each arm positively and automatically insure that every square foot of tank bottom is swept at each revolution.

* Trade Mark, Reg. U. S. Pat. Off.

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THE DORR COMPANY · ENGINEERS · STAMFORD, CONN.
Associated Companies and Representatives in the principal cities of the world

LEADITE

Trade Mark Registered U. S. Pat. Office

Jointed for . . . Permanence with LEADITE

Generally speaking, most Water Mains are buried beneath the Earth's surface, to be forgotten,—they are to a large extent, laid for permanency. Not only must the pipe itself be dependable and long lived,—but the joints also must be tight, flexible, and long lived,—else leaky joints are apt to cause the great expense of digging up well-paved streets, beautiful parks and estates, etc.

Thus the "jointing material" used for bell and spigot Water Mains MUST BE GOOD,—MUST BE DEPENDABLE,—and that is just why so many Engineers, Water Works Men and Contractors aim to PLAY ABSOLUTELY SAFE, by specifying and using LEADITE.

Time has proven that LEADITE not only makes a tight durable joint,—but that it improves with age.

The pioneer self-caulking material for c. i. pipe.
Tested and used for over 40 years.
Saves at least 75%

THE LEADITE COMPANY

Girard Trust Co. Bldg. Philadelphia, Pa.

No Caulking